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Atlantic salmon (*Salmo salar* L.) smolt production estimates and biological characteristics from tributaries and the Restigouche River, 2002 and 2003

Production et caractéristiques biologiques du stade saumonneau du saumon atlantique (*Salmo salar* L.) des tributaires et de la rivière Restigouche, en 2002 et 2003

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ABSTRACT

This document presents the results of Atlantic salmon (*Salmo salar* L.) smolt monitoring programs in the Kedgwick River, Little Main Restigouche River and in the main stem of the Restigouche River in 2002 and 2003. The objective of the studies was to estimate the annual smolt production from the tributaries and for the entire Restigouche River. Run-timing of smolts from the Kedgwick River, the Little Main River and in the lower portion of the river was similar and attributable to the quick migration of smolts from the upper tributaries. Smolts from the Restigouche River were 12.5 to 13.0 cm fork length. Smolt production rate from the Kedgwick River in 2003 was about 4 smolts per 100 m^2. The smolt production estimate for the Restigouche River overall in 2003 was estimated at 403,000 fish or 1.4 smolts per 100 m^2. There is a large migration of one-year old parr in the spring out of the Kedgwick River and the Little Main Restigouche River, presumably to the main stem of the Restigouche River. There were diverse and dynamic movements of lamprey, eel, blacknose dace and stickleback at the tributaries and the main stem of the river. The rotary screw trap technology has demonstrated its utility in monitoring Atlantic salmon smolts and parr as well as the diversity of other species present and migrating in the Restigouche River in the spring.

RÉSUMÉ

Les résultats des campagnes de suivi de saumonneau du saumon atlantique (*Salmo salar* L.) des rivières Kedgwick, Little Main et le bassin versant de la rivière Restigouche pour les années 2002 et 2003 sont présentés. Le but de ces études était l'estimation de la production annuelle de saumonneau des tributaires et pour la rivière Restigouche en entier. Le synchronisme de la dévalaison des saumonneaux des rivières Kedgwick et Little Main était similaire à celui du bas de la rivière, ce qu'on attribuait à la migration rapide des saumonneaux des tributaires en amont. Les saumonneaux de la rivière Restigouche mesuraient entre 12,5 et 13,0 cm longueur à la fourche. Le taux de production de saumonneau de la rivière Kedgwick se situait à environ 4 saumonneaux par 100 m^2. La dévalaison totale de la rivière Restigouche en 2003 a été estimée à 403 000 poissons, soit 1,4 saumonneau par 100 m^2. On a observé une dévalaison printannière importante de tacon âgé d'un an dans les rivières Kedgwick et Little Main, on présume pour aboutir dans le tronçon principal de la rivière Restigouche. On a aussi observé des mouvements divers et dynamiques de lamproie, anguille, naseux noir, et épinoche dans les tributaires et le tronçon principal. La trappe rotative est un engin de pêche efficace pour capturer les saumonneaux et tacons de saumon atlantique en autant qu'une gamme d'espèces diverses de poissons en dévalaison printannière dans la rivière Restigouche.

1.0 INTRODUCTION

The Restigouche River is the largest watershed within Salmon Fishing Area 15 (SFA 15; Baie des Chaleurs) draining about 10,000 km^2 and emptying into the Gulf of St. Lawrence at the head of Chaleur Bay. The Restigouche River and part of its tributary, the Patapedia River, define the provincial borders of New Brunswick and Québec. There are three main tributaries branching off the main stem of the Restigouche River before the latter bifurcates about 108 km above head of tide into the Little Main Restigouche River heading west and northwest and the Kedgwick River heading northwest (Fig. 1). The lower most tributary is the Matapedia River which drains southerly into the Restigouche River about 10 km above the head of tide. The Matapedia River is entirely contained within the province of Québec. The Upsalquitch River branches southward about 22 km above the head of tide and is contained entirely in New Brunswick. The Patapedia River branches northwest from the main stem at 73 km above head of tide. It borders the two provinces for 35 km of its length with the remaining headwaters within the province of Québec.

The river is accessible to salmon along its entire length and is not obstructed by natural or artificial barriers. The salmon run is predominantly early (before September 1) and comprised of generally equal numbers of small salmon (< 63 cm fork length) and large salmon (>= 63 cm fork length). Small salmon are mostly fish which have spent one year at sea (1SW) before returning to the river to spawn. Large salmon are comprised of about 70% fish which have spent two years at sea (2SW), 30% fish which spent three years at sea (3SW) and previous spawners (Randall 1984).

Historical juvenile surveys in Restigouche (NB) and recently in Quebec tributaries indicated that there has been an increased abundance of juveniles associated with an increased escapement of salmon after 1984 as a direct result of major management initiatives (commercial moratorium, mandatory catch and release of large salmon) (Chaput et al. 2000). Despite increased juvenile abundance, adult returns have not increased to anticipated levels. It is not known if increased juvenile abundance has resulted in increased smolt production and whether sea survival is the greater constraint on adult abundance. Estimates of smolt production from individual tributaries and the river overall would provide the missing life stage information to assess the relative roles of freshwater production and sea survival in defining adult Atlantic salmon abundance.

This paper presents the results of Atlantic salmon smolt monitoring programs in the Kedgwick River, Little Main Restigouche River and in the main stem of the Restigouche River in 2002 and 2003. Estimates of smolt production for the upper portion of the Little Main Restigouche River in 2002, Kedgwick River and the Restigouche River overall for 2003 are provided. Timing of the catches and characteristics of Atlantic salmon and other species are provided and compared among the tributaries and to the main stem portion of the river near the head of tide.

2 MATERIALS AND METHODS

2.1 Operations in 2002

A total of four rotary screw traps (RST) (Manufacturer: EG Solutions Inc. http://www.screwtraps.com) were installed in the Restigouche River in May 2002 (Fig. 1). The RSTs were located as follows:

1. One 1.52 m (5-foot) diameter RST was installed at one-mile bridge on the Kedgwick River. (Fig. 2).
2. One 2.44 m (8-foot) diameter RST was installed at Boston Brook Lodge in the Little Main Restigouche (Fig. 3). and
3. Two 1.52 m (5-foot) diameter RSTS were installed in the lower portion of the Restigouche River approximately at the head of tide, one on the south shore (NB side) of the river at Butters Island and the other on the north shore of the river (Québec side) at Moses Island (Fig. 4).

The RST in the Kedgwick River was operated collaboratively between the Department of Fisheries and Oceans (DFO), Fraser Lodge and MSRT (Management of the Salmon of the Restigouche and its Tributaries). The RSTs in the lower portion of the Restigouche River were operated collaboratively by the Listiguij First Nation and DFO. The RST in the Little Main Restigouche was operated as part of a larger environmental program by J.D. Irving Ltd.

The RST in the Kedgwick River was installed using an overhead cable connected to the abutments at one-mile bridge (permission received from Bowater Canada Inc.). The RST in the Little Main Restigouche was installed using an overhead cable connected to trees. The lower Restigouche River RSTs were secured in position using two instream anchors for each RST. The anchors consisted of 1-1.25 m steel pipe, driven into the substrate, to which was attached approximately 40 m of 10 mm steel cable that was attached to the RST.

Operating dates for the RSTs in 2002 are summarized in Table 1. Except for intermittent blockages with debris, the Kedgwick River RST was operational May 7 and was removed on June 19. The Little Main Restigouche RST operated from May 7 to June 19 with the exeption of May 8 to May 13 due to high water. The Restigouche River RSTs were installed late in 2002 but they operated continually from May 30 until removal on 20 June for the north shore RST and 28 July for the south shore RST.

Water level at the Kedgwick River RST location was recorded daily from a metal stake driven into the river bottom at the start of the season. Water temperatures were recorded daily when the RST was fished and continuous hourly temperatures were obtained using a data logger (VEMCO Minilogger). The revolutions per minute (RPM) of the RSTs were measured and recorded daily, once upon arrival and again prior to departure (after cleaning).

Fish were sampled from the RSTs once per day, in the morning. All fish were identified to species (or species group) and counted. Salmon parr were categorized on the basis of fork length (less than 10 cm) and by coloration (distinct parr marks, lack of black edges on fins). Atlantic salmon with a missing adipose fin were recorded as originating from satellite rearing or hatchery programs of the Restigouche. Otherwise, salmon with an intact adipose fin were considered wild

(i.e. progeny of natural spawning in the river).Fork length (to the nearest 0.1 cm) was obtained from all Atlantic salmon (*Salmo salar* L.) juveniles which were not smolts and from up to 25 Atlantic salmon smolts. Total length (to the nearest 0.5 cm) was obtained from all American eel (*Anguilla rostrata* L.) and all sea lamprey (*Petromyzon marinus* L.) catches.

A subsample of five salmon smolts was sacrificed daily from the Kedgwick River RST for determination of sex, weight (to the nearest 0.1 g) and age (from scale samples). Most of the remaining salmon smolts were tagged below the dorsal fin with individually numbered clear streamer tags (Hallprint, 53 mm long by 3 mm wide), placed in plastic recovery buckets with circulation holes, transported and released about 1.5 km upriver. Tag numbers of recaptured smolts at the RST were recorded before subsequent release. Unmarked smolts were examined for tagging scars (lost tags) before release.

Sampling protocols at the Little Main Restigouche RST were similar to those of the Kedgwick with the exception that all salmon smolts were measured for length and no sacrifice samples were retained. Only salmon and trout were measured, all other fish were identified to species and counted. Tagged salmon smolts were recycled and released about 1.5 km upriver at Ledge Pool.

Sampling protocols at the lower Restigouche wheels were identical to those from the Kedgwick with the exception that there was no tagging of salmon smolts and no smolts were sacrificed for biological characteristics.

The efficiency of the RSTs for catching Atlantic salmon smolts was determined using mark and recapture experiments. Stratified (Darroch model: Arnasson et al. 1996) and simple (Bayesian and Peterson models: Gazey and Staley 1986) models were adjusted to the data. Survival of tagged smolts was considered to be 100% during the duration of the experiments.

2.2 Operations in 2003

RST installations in 2003 were similar to those in 2002 with the following exceptions:

1. The 2.44 m diameter RST was installed in the Kedgwick River and the 1.52 m diameter RST was installed at Boston Brook Lodge in the Little Main Restigouche, and
2. The location of the RST on the north shore of the river (Québec side) was moved to the upper north side of the channel at Moses Island (Fig. 4).

Collaborators in the projects in 2003 were identical to those in 2002. Operating dates for the RSTs in 2003 are summarized in Table 1.

Sampling, tagging and release protocols for fish in 2003 were identical to those of 2002 with the following exception. Atlantic salmon smolts were tagged at the lower Restigouche wheels in 2003 using individually numbered clear and green streamer tags. Tagged smolts were recycled upstream of the traps and released at the locations identified in Figure 4 according to the following design:

1. all smolts from the north side RST were released at the north side release point daily, and
2. tagged smolts from the south side RST were released one day at the north side release point and on alternate days at the south side release point (Fig. 4).

The efficiency of the RSTs for catching Atlantic salmon smolts was determined using mark and recapture experiments. Stratified (Darroch model: Arnasson et al. 1996) and simple (Bayesian and Peterson models: Gazey and Staley 1986) models were adjusted to the data. Survival of tagged smolts was considered to be 100% during the duration of the experiments.

3 RESULTS

3.1 Kedgwick River RST

In both years of opertion, the water levels in the Kedgwick River decreased almost continually by about one metre from the start to the end of operations (Fig. 5). Water temperatures in the morning were about 4°C when operations began in both years and remained below 8°C until May 24 in 2002 but only until May 19 in 2003 (Fig. 5). Overall, water temperatures remained cooler in 2002 relative to 2003.

In 2002, the 1.52 m RST operated within a range of 8 to 12 RPM with the highest RPMs at the start of operations and declining with decreases in water level. In 2003, the 2.44 m RST operated within a slower range of 5 to 9.5 RPM.

Catches

During the period of operation in 2002, the RST in the Kedgwick River captured a total of 10 species representing almost 2,900 individuals (Table 2). The most abundant catches were Atlantic salmon (92% of total individuals) followed by American eel (2.5% of total) and sea lamprey ammocoetes (2.4% of total). Mortalities totaled 18 fish including 15 Atlantic salmon parr (1% of catch), one stickleback (7% of catch) and two round whitefish (100% of catch).

During 2003, the RST in the Kedgwick River captured a total of 11 species representing over 6,000 individuals (Table 3). The most abundant catches were Atlantic salmon (82% of total individuals) followed by sea lamprey ammocoetes (13% of total) and American eel (2.3% of total). Atlantic salmon parr comprised 64% of the total salmon catch as compared to 52% in 2002. The most striking change in 2003 relative to 2002 was the large number of sea lamprey ammocoetes sampled in 2003. Mortalities totaled 28 fish (0.4% of total catch) including 22 Atlantic salmon (21 of 22 were parr = 0.4% of catch), 3 of 7 gaspereau, one speckled trout, one white sucker, and one northern red-belly dace.

Run-timing

Most (90%) of the Atlantic salmon smolts were captured over a 13 day period between May 20 and June 1 in 2002 with a median date of May 29 (Table 2; Fig. 6). These peak catches corresponded to the warming of the water temperatures above 8°C in the morning (Fig. 5, 6). The smolt migration was essentially finished by June 3. Atlantic salmon parr were captured throughout the trapping period in 2002 regardless of water temperature (Table 2; Fig. 5, 6). With the exception of the days when smolts were running, salmon parr were the dominant catch at the Kedgwick RST. Emerging and drifting young-of-the-year (YOY) were first captured at the RST on 14 June (Table 2; Fig. 6). These YOY salmon measured between 3.0 and 3.3 cm fork length.

In 2003, most (90%) of the Atlantic salmon smolts were captured during the 16 day period of May 19 to June 3 with a median date of May 28, similar to 2002 (Table 3; Fig. 7). As in 2002, the run of smolts was stimulated by warming of water temperatures above 8°C in the morning (Fig. 5, 7). Smolt migration was essentially finished by June 9. Salmon parr were the dominant daily catch except during the period of peak smolt migration when parr catches declined; parr catches increased after the smolt catches decreased (Fig. 7). No emerging and drifting young-of-the-year salmon were captured at the RST in 2003.

American eel catches were more important in June relative to May 2002 whereas sea lamprey ammocoetes were captured principally in May (Table 2). In 2003, American eel catches were again more important in June whereas sea lamprey ammocoete run-timing was most similar to that of salmon smolts, peaking during May 23 to June 4 (Table 3; Fig. 8).

Biological characteristics

Atlantic salmon smolts from the Kedgwick River were predominantly 12.5 cm to 13.0 cm fork length in 2002 and 2003 (Fig. 9). The maximum observed length in both years was of 16.7 cm. Atlantic salmon parr were primarily one year old fish measuring 5.5 to 6.0 cm fork length (Fig. 9). There were few age 2 year old parr in the catches (fork lengths > 7 cm).

There was no significant difference in the length-weight relationship of males and females in both 2002 and 2003, however there was a significant difference ($P<0.01$) in the intercept of the log transformed relationship between years (Fig. 10). Smolts in 2002 weighed less than smolts in 2003 of comparable size. The length-weight equations for each year are:

- 2002: Log_{10}Whole weight (g) = -1.97 + 2.70*Log_{10}Fork length (cm)
- 2003: Log_{10}Whole weight (g) = -1.66 + 2.70*Log_{10}Fork length (cm)

In 2002, the smolt run was estimated to have comprised 54% female (N = 71) whereas in 2003, the female smolts were estimated to have comprised 44% of the run (N = 91). Ageing data has not been completed.

Sea lamprey were predominantly ammoecetes, both brown free-living and newly metamorphosed silver individuals measuring between 6 and 28 cm total length (Fig. 11). American eel were of a broad size range (15 to 85 cm total length) but most were within 15 to 40 cm total length (Fig. 11). In both years of sampling, most of the fish caught were small

individuals, the exceptions being the two round whitefish captured in 2002 (25 and 30 cm fork length), the gaspereau in 2003 (over 30 cm fork length), and the few large American eel.

Estimation of total smolt run

In 2002, a total of 1,198 smolts were tagged, recycled upriver and released (Table 4). Only five recaptures were observed at the Kedgwick RST of which one was identified by a tagging scar. There were too few recaptures to derive a capture efficiency for the RST. Three of the four tagged smolts recaptured at the RST were recovered within 24 hours of release. The fourth recovery took four days to be recaptured at the RST.

In 2003, a total of 1,704 smolts were tagged, recycled upriver and released (Table 5). A total of 49 individuals were subsequently recaptured at the RST, most within 24 hours of release (Table 5; Appendix 1). Based on the 1,696 tagged smolts released between May 10 and June 13, 49 recaptures and a total catch of 1,800 smolts (Appendix 1), an estimated 64,000 smolts migrated from the Kedgwick River in 2003 (95% C.I. 49,000 to 86,000) (Fig. 12). The efficiency of the wheel was estimated at 2.8% (95% C.I. 2.1%-3.7%). The stratified estimate (Darroch) of the smolt run based on four tagging and four recapture periods was 50% higher than the Bayes estimate; 91,850 fish (95% C.I. 55,100-128,600) (Table 6). The efficiency of the RST increased from about 1.5% at the start to over 8% for the tail end of the smolt run, with an overall efficiency estimate of 2.0% for the season (Table 6; Fig. 13).

The stratified estimator is a better representation of what was occurring in the context of efficiency at the RST. The RST was highly efficient in June during the tail end of the run and less so during the peak period of the run. Water levels would affect the wetted width of the river and one possible explanation for the higher efficiency at the end of the run is that the river was directed almost entirely to the side of the river of the RST when relative water levels fell below 10 cm (after June 3 in 2003) (Fig. 2, 5).

3.2 Little Main Restigouche RST

The average daily water temperatures in 2002 were about 4°C when operations began and by June 1, average temperatures had risen to above 12°C. In 2003, the average daily temperature was 5°C at the start on May 14 and remained at about 10°C into June 15. The RPM operating range of the RST was not recorded in 2002. In 2003, the RST operated within a range of 7 to 13.5 RPM with the higher RPM registered at the start of the season at higher water levels.

Catches

During the period of operation in 2002, the RST in the Little Main Restigouche River captured a total of seven species totalling almost 900 individuals (Table 7). The most abundant catches were Atlantic salmon (75% of total individuals) followed by sea lamprey ammocoetes (17% of total) and blacknose dace (5% of total catch). Mortalities totaled 5 fish (0.6% of total catch), all Atlantic salmon represented by two parr (0.5% of parr catch) and three smolts (1.2% of smolt catch).

During 2003, the RST captured a total of nine species totaling almost 1,300 individuals (Table 8). The most abundant catches were Atlantic salmon (61% of total individuals) followed by sea lamprey ammocoetes (26% of total) and blacknose dace (7% of total) (Table 8). Atlantic salmon parr comprised 81% of the total salmon catch as compared to 63% in 2002. Mortalities totaled six fish (0.5% of total catch) including three Atlantic salmon parr (0.5% of catch) and three stickleback (33% of total catch).

Run-timing

Most (90%) of the Atlantic salmon smolts were captured over a 15 day period between May 18 and June 1 in 2002 with a median and peak catch date of May 24 (Table 9; Fig. 14). The smolt migration was essentially finished by June 3. Atlantic salmon parr were captured throughout the trapping period in 2002, with peak catch occurring on May 20 and decreasing thereafter (Table 8; Fig. 14). No emerging and drifting young-of-the-year were observed during the period of operation in 2002.

In 2003, most (90%) of the Atlantic salmon smolts were captured during the 25 day period of May 18 to June 12 with a median and peak date of May 28, four days later than in 2002 (Table 10; Fig. 15). Smolt migration was observed into June 25 when the operations finished. Salmon parr were the dominant daily catch except during the period of peak smolt migration when parr catches declined; parr catches increased after the smolt catches decreased (Fig. 15). Salmon alevin with a yolk sac attached was observed on June 17 and large numbers (100s) of emerging and drifting young-of-the-year salmon were captured on June 23 and 25.

Sea lamprey ammoecete migrations were observed throughout the period of operation, peaking during the May 28 to June 6 period in 2002 (Fig. 16). In 2003, sea lamprey ammoecete migration was very similar to that of salmon smolts, with the first ammocoetes observed on the first day of operation (May 7), peaking on May 28 and declining but consistent into June 25 when operations were completed (Fig. 17). Blacknose dace were first observed on May 22 with consistent numbers sampled until the end of operations in 2002 (Fig. 16) whereas in 2003, dace were observed from the first day of operation (May 7) and increasing into June (Fig. 17).

Biological characteristics

Atlantic salmon smolts from the Little Main Restigouche River were predominantly 13.0 cm fork length in 2002 and 14.0 cm fork length in 2003 (Fig. 18). The maximum observed length in both years was of 16.8 cm. Atlantic salmon parr were primarily one year old fish measuring 5.0 to 6.5 cm fork length (Fig. 18). There were few age 2 year old parr in the catches in either year (fork lengths > 7 cm in 2002, > 8 cm in 2003).

Estimation of total smolt run

In 2002, a total of 216 smolts were tagged, recycled upriver and released (Table 9). A total of 19 were recaptured at the RST (Table 9; Appendix 2). The majority were recovered within one day post-release but one smolt took 15 days to re-initiate its downstream migration (Appendix 2). Based on the 216 tagged smolts released between May 15 and June 9, 19 recaptures and a total catch of 223 unmarked smolts (Appendix 2), an estimated 2,700 smolts migrated from the Little Main Restigouche River (at Boston Brook) in 2002 (95% C.I. 1,800 to 4,400) (Fig. 19). The efficiency of the wheel was estimated at 8.3% (95% C.I. 5.0-12.6%). The stratified estimate (Darroch) of the smolt run based on two tagging and two recapture periods was almost identical to the Bayes estimate; 2,721 fish (95% C.I. 1,454 - 3,988) (Table 11). The efficiency of the RST increased from about 7% at the start to over 12% for the tail end of the smolt run, with an overall efficiency estimate of 8% for the season (Table 11).

In 2003, only two recaptures were recovered of 145 smolts tagged, recycled and released. Consequently, no estimate could be derived (Table 10).

3.3 Restigouche River RST

The primary effort in 2002 was to locate and assess possible sites for installation of the RSTs. Installation in 2002 was late with both RSTs operational by May 30 (Table 1). The south side RST was operated until July 28 whereas the north side RST was removed on June 20. In 2003, the south side RST began operation on May 13 whereas the north side RST began operation on May 15 (Table 1). Both RSTs operated until June 23 in 2003. Water temperatures in the morning were above 10°C when operations began on May 31 (Fig. 20). Water temperatures had risen above 20°C by late June 2002 and by the end of July, morning water temperatures were between 15°C and 20°C (Fig. 20). In 2003, water temperatures in the morning at fishing time were 5°C but rose quickly to near 10°C by May 18 and remained around 10°C until June 6 (Fig. 20). This pattern of seasonal warming in 2003 was identical to that observed at the Kedgwick River RST.

In 2002, the south side RST operated within a range of 4 to 10 RPM whereas the north side RST operated between 3 and 6.5 RPM. Both wheels were subject to tidal water incursions during the peak high tides in June (June 14-15). In 2003, the south side RST operated within a range of 4 to 12.5 RPM while the north side RST (relocated from 2002) operated within a range of 8 to 13 RPM. The south side RST was again affected by the high tides. The higher RPM ranges, above 8 RPM, represent ideal operating conditions for these gear.

Catches

During the period of operation in 2002, the RST on the south side of the Restigouche River captured about 5,200 fish representing 14 species (Table 12). The most abundant catches over the May 31 to July 28 time period were stickleback followed by rainbow smelt and salmon (Table 12). Rainbow smelt and salmon smolt catches were more abundant at the start of the season and dropped off to zero by June 18 whereas salmon fry were first captured on June 14 and were most abundant in late July. American eel catches were most important in late May and

early June with few captured in July. Stickleback were most abundant in July whereas fallfish (chub) were more abundant in June (Table 12). Only one mortality was recorded at the RST: the single American shad.

The north side RST was operated for a short period in 2002 and captured less than 600 fishes representing eight species (Table 13). Rainbow smelt, salmon and fallfish (chub) were the most abundant species captured. Young-of-the-year salmon were first captured on June 14 (Table 13).

The RSTs were installed between May 14 and 16 in 2003 (Table 1). The RST on the north side of the river captured a total of 6,006 fish in 2003 representing 12 species (Table 14). The most abundant catch was Atlantic salmon (64% of total) of which smolt was the dominant life stage at 47% of total catch of fishes (Table 14). Stickleback and white sucker were the most abundant secondary species catches. Mortalities at the north side RST totaled four fish (0.1% of total catch), all Atlantic salmon smolts. At the south side RST, just under 6,000 fishes were captured representing a similar species diversity as the north side RST (Table 15). All life stages of Atlantic salmon represented about 30% of the total catch. Stickleback was almost as abundant in the catches as salmon. Other abundance species included rainbow smelt and fallfish (chub) (Table 15). American eel were equally abundant at both RSTs in 2003 and catches were similar to those at the Kedgwick River RST in 2003. Very few lamprey ammocoetes were captured at the downriver wheels compared to the RST in Kedgwick River (Tables 3, 14, 15). Mortalities at the south side RST totaled 10 fish (0.2% of total catch) including nine Atlantic salmon and a single speckled trout.

Run-timing

The RSTs in 2002 were installed and sampled only the tail end of the Atlantic salmon smolt run. The RST on the south side sampled the drift of young-of-the-year salmon which started on June 14 and was notable due to the large drift which occurred in late July (Table 12). The majority of the American eel catch occurred in June whereas stickleback were abundant during the entire period of operation.

In 2003, the RSTs were in place to sample the Atlantic salmon smolt migration. Most (90%) of the Atlantic salmon smolts were captured over a 16 day period between May 20 and June 4 at the south side RST with a median date of May 28 (Table 14; Fig. 21). The majority of the smolt migration occurred during the period when morning water temperatures were between 8 and 10°C (Figs. 20, 21). Most (90%) of the Atlantic salmon smolts at the north side RST were captured during the 15 day period of May 21 to June 4 with a median date of May 29 (Table 12; Fig. 21). Salmon parr catches were more important in May at both locations (Fig. 21). Emerging and drifting young-of-the-year salmon were captured at both locations in 2003 commencing on June 15 and catches of these were more important at the north side RST (Tables 14, 15).

Biological characteristics

Atlantic salmon smolts captured in the lower Restigouche River were predominantly 11.5 to 13 cm fork length in 2002 and 2003 (Fig. 22). The maximum observed length of smolt was 22 cm in 2002 and 20.3 cm fork length in 2003. Atlantic salmon parr were primarily one year old fish measuring 5.5 to 6.0 cm fork length (Fig. 22). There were few age 2 year old parr in the catches (fork length > 7 cm).

There was a significant difference ($P<0.01$) in the length-weight relationship of male and female smolts at the lower RSTs in 2003 in terms of difference in the slope of the log transformed data (Fig. 23). Female smolts were signicantly heavier than male smolts of comparable size. The length-weight equations for males and females are:

- Males: Log_{10}Whole weight (g) = -1.74 + 2.814*Log_{10}Fork length (cm)
- Females: Log_{10}Whole weight (g) = -1.74 + 2.815*Log_{10}Fork length (cm)

In 2003, the female smolts were estimated to have comprised 32% of the run (N = 95). Ageing data has not yet been completed.

Sea lamprey were predominantly ammoecetes, both brown free-living and newly metamorphosed silver individuals measuring between 9 and 19 cm total length. American eel were of a broad size range (10 to 85 cm total length) but most were within 15 to 40 cm total length.

Estimation of total smolt run

There was no estimate of the total smolt run from the Restigouche River in 2002.

In 2003, smolts were tagged, recycled upstream, and released at two locations (Fig. 4; Table 16, 17). Of the 1,062 smolts tagged, recycled and released from the south side RST, only four recaptures were observed again; three at the south side RST and all from releases on the south side, and one at the north side RST from a north side release (Table 16). Of the 2,050 smolts tagged, recycled and released from the north side RST, three were recaptured at the north side RST and one was recaptured at the south side RST (Table 17). The days to recapture from these releases ranged from one to three days with the smolts released on the south side taking the longest, two to three days compared to one day for the north side releases (Table 18). No smolt run estimate was derived from this mark and recapture experiment.

A total of 19 smolts previously tagged at the Kedgwick RST were subsequently recaptured at the lower river RSTs, most of them (17 of 19) at the north side RST (Table 16, 17). Tagged smolts were recoverd within three to six days of release in Kedgwick River and most (13 of 19) were recovered within 3 to 4 days (Table 18). One tagged smolt from the Little Main Restigouche was recaptured at the north side RST, within four days post-release (Table 17).

Based on the recaptures (R = 19) of smolts tagged (M = 1,704) at the Kedgwick River RST and a total catch including recaptures at the two lower river RSTs (C = 4,219), the Bayes population

estimate (median) of the smolt run in 2003 is 403,000 fish (95% C.I. 262,000 to 670,000 smolts) (Fig. 24). The RSTs combined sampled 1.0% of the smolt run (95% C.I. 0.6% to 1.6%). A stratified estimate was not attempted for this experiment because the probability of recapture of the tagged groups did not suggest a change over time (Fig. 25) as was the case for the Kedgwick experiment (Fig. 25) and there were no obvious groups in the recoveries at the RSTs (Appendix 3).

3.4 Among tributary and river comparisons

There are differences in the relative abundance of fish between the tributary monitoring locations and the downriver location (Table 19). Parr have been more abundant than smolts in the tributary RSTs in both years than at the downriver location where parr were a minor component in the 2002 catches and less than 20% of the smolt catch in 2003 (Table 19). In addition, lamprey ammoecetes are abundant in the spring, more so in 2003 than in 2002 at both tributary sites whereas they are essentially absent from the downriver catches (Table 19). This contrasts with eel catches which are make up a higher proportion of the catch at the downriver locations than in the tributary sites and are relatively absent in the Little Main Restigouche (Table 19). Salmon are the dominant proportion of the catch in the tributaries but other species are more abundant overall in the lower portion of the river.

Run timing has been similar within the tributaries with median date of the smolt catch during May 24 to 29, similar to that in the lower portion of the river (Table 19). The smolt migration was a few days later in 2003 and finished later than in 2002 (Table 19).

There were some consistent but minor differences in fork length of smolts. Smolts from the Little Main were about 0.5 cm longer than those from either the Kedgwick or the main Restigouche (Tukey paired test: $P < 0.05$) (Table 19). Smolts in 2003 were longer than those in 2002 (t-test: $P < 0.05$) in the Kedgwick River but were of similar size in the Little Main Restigouche and the main Restigouche in those years.

There was a significant difference in the length-weight relationship of smolts from the main Restigouche relative to smolts from the Kedgwick River in 2003 ($P<0.01$) (Fig. 23). Kedgwick River smolts weighed less at a given length than smolts sampled at the lower river RSTs:

- main Restigouche: Log_{10}Whole weight (g) = -1.68 + 2.753*Log_{10}Fork length (cm)
- Kedgwick: Log_{10}Whole weight (g) = -1.68 + 2.720*Log_{10}Fork length (cm)

At a fork length of 12.5 cm, a smolt from the Kedgwick River had an average weight of 20.2 g, whereas a smolt from the main Restigouche averaged 21.9 g.

The habitat area for the Restigouche River available for the production of juvenile salmon has been estimated at 29.8 million m^2 (Randall 1984). Habitat area for the Kedgwick River has been estimated at 2.29 million m^2 (Locke 1998). The habitat area in the Little Main Restigouche River above the RST location at Boston Brook is about 1.3 million m^2 (C. Connell, unpublished data). Based on these habitat area estimates, the production rate of smolts from the Little Main Restigouche River above Boston Brook in 2002 was 0.2 smolts per 100 m^2, the Kedgwick River production in 2003 was estimated at 4.0 smolts per 100 m^2, and the Restigouche River overall in 2003 at 1.4 smolts per 100 m^2 (Table 19).

4 DISCUSSION

Run-timing of smolts from the Kedgwick River, the Little Main River and in the lower portion of the river was similar and attributable to the quick migration of smolts from the upper tributaries. Smolts from the Kedgwick River and the Little Main Restigouche in 2003 took 3 to 4 days to migrate downriver, more than 110 km. Due to the recycling of tagged smolts upriver and the delays associated with capture and sampling, it is more likely that smolts could complete the migration from the mouth of the Kedgwick to tidal waters within two days. The only previous monitoring of smolt migrations in the Restigouche River was conducted in 1973 to 1976 using a tidal trapnet and the smolt catches peaked in the first part of June in those years (Peppar 1982).

Smolts from the Kedgwick River and from the Restigouche River overall are of similar size, at 12.5 to 13.0 cm fork length, with the Little Main Restigouche smolts being slightly larger. These sizes are less than the average fork lengths of 14 to 15 cm for the smolts migrating in 1973 to 1976 (Peppar 1982). They are, however, of comparable size to smolts from the Miramichi River (Chaput et al. 2002).

The low proportion female in the Kedgwick River and Restigouche River samples in 2003 was unexpected as observations from numerous other rivers over time indicate that multi-sea-winter salmon stocks like the Restigouche tend to have a higher proportion female in the smolt runs (Chaput et al. 2002; Caron et al. 2002).

In 2003, smolt production from the Kedgwick River was most likely over 90,000 fish with a 97% probability that there were at least 56,000 smolts leaving the river. This translates to a production rate of about 4 smolts per 100 m^2, and at least 2.4 smolts per 100 m^2. A high production rate from this tributary would be expected given its habitat characteristics and the high parr densities observed in this river (Chaput et al. 2000). The low production rate in the Little Main Restigouche above Boston Brook was unexpected and could be attributed to several factors including extensive outmigration of one-year old parr in the spring (as observed in 2002 and 2003) and a fall migration of "pre-smolts" as was observed in 2002 and 2003 (J.D. Irivng Limited, unpublished data). However, an important migration of one-year old parr was also observed on the Kedgwick River in the spring in both years of sampling and the production rate of spring migrating smolts remained high.

Smolt production estimate for the Restigouche River overall in 2003 was estimated at 403,000 fish with a 97% probability that there were at least 262,000 smolts leaving the river. For a previously tabled habitat area value of 29.8 million m^2, this translates to a production rate from the river overall of 1.4 smolts per 100 m^2 and at least 0.9 smolts per 100 m^2. Production rates from the Northwest Miramichi River over four years of sampling have varied between 1 and 2.3 smolts per 100 m^2 and between 1.1 and 1.8 smolts per 100 m^2 for the Southwest Miramichi (DFO 2003). These rates encompass the estimated production rate of the Restigouche in 2003 which is substantially better than rates for the Nashwaak River (tributary of the Saint John River, New Brunswick) (0.2 to 0.5 smolts per 100 m^2 between 1998 and 2002) and the LaHave River (Nova Scotia) (0.2 to 0.4 smolts per 100 m^2 between 1996 and 2002) (DFO 2003).

The St. Jean River (Gaspé peninsula) and de la Trinité River (Québec north shore) are of similar relative size to the Kegwick River, between 2.1 and 2.3 million m^2, but the former rivers empty directly to the sea (Caron et al. 2002). Production rate of the River St. Jean has varied between 2.2 and 6.7 with a median rate of 4.4 smolts per 100 m^2 of wetted habitat during 1989 to 2001 (Caron et al. 2002). de la Trinité River production has varied between 1 and 4.6 with a median rate of 2.8 smolts per 100 m^2 since 1984 (Caron et al. 2002). The Kedgwick River production rate in 2003 is within the range of values observed for those comparable sized rivers.

The smolt run from the Kedgwick River in 2003 represented 22% of the total smolt production from the river whereas the habitat area of the Kedgwick represents about 8% of the wetted habitat area for the whole river. Smolt production from the main stem of the Restigouche River, representing 41% of the total area for the river, was expected to be substantially less than the production rate in at least the Kedgwick River. Production rates in tributaries of large rivers tend to be higher than the integrated rate for the entire large river as observed from smolt monitoring programs on the Miramichi River and from adult salmon monitoring programs at headwater sites in the Miramichi (Chaput et al. 2001).

In the spring, there is an important movement of one-year old parr out of the Kedgwick River and the Little Main Restigouche River, presumably to the main stem of the Restigouche River. It is not known if these individuals represent only a localized movement but emigration of this life stage is consistent with density dependent migration from the Kedgwick and probably contributes to an important portion of the parr population in the main stem of the river.

Based on the Kedgwick River smolt releases, it was estimated that the two RSTs in the lower portion of the river captured about 1% of the smolt run. It appears that most of the smolts from upriver use the north side and likely the middle channel near the head of tide in the Restigouche River (Fig. 4). Attempts to tag and recycle smolts from the lower Restigouche RSTs for calibration purposes were not successful in 2003 with only 7 recaptures from over 3,100 tagged and recycled smolts. The cause of the low recaptures may include predation but more likely bias associated with the point of release to migration using the middle channel which did not have an RST. If smolts from the lower RSTs are to be tagged and recycled in order to improve the estimates of RST efficiency, the release location will have to be much farther upstream to allow the smolts to redistribute more effectively among the channels.

The diversity and dynamics of catches of lamprey, eel, blacknose dace and stickleback and their abundance and movements among the tributaries and the lower river RSTs was an unexpected result from the RST monitoring program. The RSTs have demonstrated to date their utility in monitoring Atlantic salmon smolts and parr as well as the diversity of other species present and migrating in the Restigouche River in the spring.

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Table 1. RST operating dates and specifics in the Restigouche River watershed in 2002 and 2003.

Operational details	Date	Time	Comment
Kedgwick River – 2002			
Start	May 7	15:00	
Finish	June 19	8:15	
Specifics	May 8 to 9	8:30 to 19:20	RST screw jammed by debris, wheel cleaned and raised, reset May 9
	May 28	8:00	RST vandalized overnight, RST pulled toward shore, holding box lock broken, very few fish in holding box, wheel relocated into main current
Little Main Restigouche River - 2002			
Start	May 7	15:00	
Finish	June 19	8:15	
Specifics	May 8 to 13		RST raised due to high water conditions
Restigouche – South shore – 2002			
Start	May 30	16:00	
Finish	July 28	9:00	
Restigouche – North shore – 2002			
Start	May 30	16:00	
Finish	June 20	9:00	
Kedgwick River – 2003			
Start	May 8	15:00	
Finish	June 19	9:20	
Specifics	June 14	9:00	RST jammed with 8-ft length of pulp wood
	June 19	9:20	RST jammed with debris
Little Main Restigouche River - 2003			
Start	May 8	15:00	
Finish	June 19	9:20	
Specifics	May 17, 25, 31, June 3, 7, 9		RST fishing but not checked
Restigouche – South shore – 2003			
Start	May 13	15:00	
Finish	June 23	8:30	
Specifics	May 27	8:50	RST jammed by log
	June 2	8:30	RST jammed by log
Restigouche – North shore – 2003			
Start	May 15	15:00	
Finish	June 23	9:00	

Table 2. Daily catches by species at the RST in the Kedgwick River, 2002. Specifics of RST operations are summarized in Table 1.

Month	Day	Sea lamprey	Atlantic salmon			Speckled trout	Round whitefish	Black-nose dace	Fine-scale dace	White sucker	American eel	Stickleback	Slimy sculpin	Salamander	Total
			Fry	Parr	Smolts										
May	8			20											20
	9														0
	10	2		12	1									1	16
	11	6		45	4			1		2					58
	12	6		38	4										48
	13	1		22	1										24
	14			39	6			6							51
	15	1		37	3										41
	16			33				2							35
	17	4		29	4										37
	18	1		59	6			1							67
	19			30	22							1			53
	20	2		67	23			1							93
	21	2		47	16										65
	22	2		62	29			1							94
	23	1		47	61			7							116
	24			36	175					1	1		1		214
	25	1		19	111			1			3				135
	26			28	87			1							116
	27	3		52	59					1					115
	28	1		1	3										5
	29	4		13	94			1							112
	30	2		20	159			3			3				187
	31	2		37	170			1			6				216
June	1			57	135				1		5	1			199
	2			57	66					1	7				131
	3	5		45	20										70
	4	6		41	4						1				52
	5	3		11	3						2				19
	6	4		44	4						2	1			55
	7			20	6			1			2	1			30
	8	1		14	2			2			5				24
	9			65							3				68
	10	1		35				3			2	2			43
	11			7			1	3	1		4				16
	12			16	1			3	1		4	3			28
	13			7				2	2		4				15
	14	1	8	20				8	3		4				44
	15	1	1	10		2		2	3	1	2				22
	16	2		25			1	8	1	1	5	1	2		46
	17		7	23				4		1	3	3			41
	18		2	46				1			2				51
	19		3	17				1	1		2	1			25
	20														
	21														
	22														
	23														
Total		65	21	1353	1279	2	2	64	13	8	72	14	3	1	2897

Table 3. Daily catches by species at the RST in the Kedgwick River, 2003. Specifics of RST operations are summarized in Table 1.

Month	Day	Sea lamprey ammocyetes			*Salmo salar*			Dace							
		Brown	Silver	Gaspereau	Parr	Smolts	Speckled trout	Black-nose	Fine scales	Northern red-belly	White sucker	American eel	Stickleback	Slimy sculpin	Total
May	8							1							1
	9	2			40		1								43
	10	10			128	3		2							143
	11	4			106	2		1							113
	12	9			118		1					1			129
	13	18	1		120	3		1							143
	14	4	2		71	4									81
	15	9			99	8	1	1							118
	16	12			115	7									134
	17	3			183	10		3							199
	18	10			226	30		4							270
	19	14	2		139	56									211
	20	15	8		122	75									220
	21	4	4		46	113						1			170
	22	18	1		41	64									124
	23	46	2		30	69									147
	24	65	2		41	75						1			184
	25	67			48	96									211
	26	69	2		46	115						2			234
	27	52	2		33	172									259
	28	55			31	127									213
	29	33			45	199						5			283
	30	32			53	146	1					2	3		237
	31	17	2		112	95						1	2		229
June	1	37	1		67	93						2	1		201
	2	31	5		90	88						2			214
	3	15	2		119	68	1	1				3	1		210
	4	31	5		147	34									217
	5	19	4		72	20						4			119
	6	23	1		103	13		8				6		1	155
	7	6			130	25		4	1		1	12	3	1	183
	8	5			120	16						11	3		155
	9	9	1	1	62	10		4			2	5	5		99
	10	4	3		61	2		1	1		2	4	2		80
	11	3	3		19	2			1		3	7	3	2	43
	12	1		1	40			1			3	3	4		53
	13		2		50	2		9				5	2		70
	14										1	1			2
	15			1	17			5		1	1	5	1		31
	16	2	1		29	1		2	1		1		1	4	42
	17	1	2	2	44	3		2	1		1	11	3		70
	18	3			30	1	1	5			1	12	1		54
	19		1	2	39	4	1	6			1	35	1	2	92
	20														
	21														
	22														
	23														
Total		758	59	7	3235	1849	7	61	5	1	17	141	36	10	6186

Table 4. Summary of smolt sampling data from the Kedgwick River RST in 2002.

		Mortality	Released					
Month	Day	Sacrificed	Injured	Sampled	Tagged	Recaptured from Kedgwick	Tag-scar	Total
May	8							0
	9							0
	10				1			1
	11	1			3			4
	12				4			4
	13	1						1
	14	1			5			6
	15				3			3
	17	1			3			4
	18	1			5			6
	19	4			18			22
	20	4			19			23
	21	3			13			16
	22	5			24			29
	23	5			55	1		61
	24	5			169		1	175
	25	5	1		105			111
	26	5			82			87
	27	5			54			59
	28				3			3
	29	5	1		87	1		94
	30	5	1		152	1		159
	31	5	1		164			170
June	1	5		1	129			135
	2	5			61			66
	3				20			20
	4				4			4
	5				2	1		3
	6				4			4
	7				6			6
	8				2			2
	9							0
	10							0
	11							0
	12				1			1
	13							0
	14							0
	15							0
	16							0
	17							0
	18							0
	19							0
Total		71	4	1	1198	4	1	1279

Table 5. Summary of smolt sampling data from the Kedgwick River RST in 2003.

		Mortality		Released						
								Recaptured from		
Month	Day	Incidental	Sacrificed	Lost	Sampled	Tagged	Tagged*	Kedgwick	Tag-scar	Total
May	8									
	9									0
	10					3				3
	11					2				2
	12									0
	13					3				3
	14					4				4
	15		1			7				8
	16					7				7
	17					10				10
	18		5			24		1		30
	19		5			51				56
	20		5			69		1		75
	21		5	1		105			2	113
	22		5			58		1		64
	23		5			62		2		69
	24		6			69				75
	25		4			92				96
	26		5			109		1		115
	27		5			164		3		172
	28		5			119		3		127
	29		5			189		5		199
	30		5	1		140				146
	31		5		1	88		1		95
June	1		5			79		9		93
	2		5			81				86
	3	1	5			60		2		68
	4		4			25		4		34
	5					18		2		20
	6					12		1		13
	7					22		3		25
	8					13		3		16
	9					6		4		10
	10						1	1		2
	11					2				2
	12									0
	13					2				2
	14									0
	15									0
	16					1				1
	17					3				3
	18					1				1
	19		1			3				4
Total		1	91	2	1	1704	1	47	2	1849

* tagged smolt accidentally released at wheel, not recycled

Table 6. Tagging, recapture and catch stratified matrix for the Kedgwick River Atlantic salmon smolt production estimate, 2003. Total catch under recapture period excludes recaptures.

		Recapture period				
Marking period	**Tagged**	May 9 - May 24	May 25 - May 30	May 31- June 2	June 3- June 19	Prop. Recaptured
May 9 - May 23	405	7	1			0.020
May 24 - May 29	742		11			0.015
May 30 - June 1	307			10		0.033
June 2 - June 13	242				20	0.083
Total catch	1696	512	843	264	181	1800
Estimated run		24,689	56,864	8,105	2,190	**Total** 91,848
(95% C.I.)						*(55,068-128,629)*
Efficiency of wheel		0.021	0.015	0.033	0.083	0.020

Table 7. Daily catches by species at the RST in the Little Main Restigouche River, 2002. Specifics of RST operations are summarized in Table 1.

Month	Day	Sea lamprey	Atlantic Salmon		Speckled trout	Black nose dace	White sucker	Stickleback	Slimy sculpin	Unidentified	Total
			Parr	Smolts							
May	8										0
	9										
	10										
	11										
	12										
	13										
	14	5	35	3							43
	15	4	21	4							29
	16	6	30	3							39
	17		2	1							3
	18	2	47	24							73
	19	2	8	14							24
	20	4	56	18							78
	21		19	8					1	1	29
	22	5	36	8		1					50
	23		18	17							35
	24	5	17	48		5	1	1			77
	25	2	10	14		1					27
	26	5	7	9		2					23
	27	5	9	3		1					18
	28	13	6	1		1					21
	29	2		16		1					19
	30	8	6	12		2			2		30
	31	11	5	9		3			1		29
June	1	12	12	19		2			3		48
	2	11	19	8		2	1		1		42
	3	13	5	1		4					23
	4	4	16			3					23
	5	15	4		1	2	1				23
	6	12	4			2					18
	7	1	8	1		4					14
	8	1	6		1	4		1			13
	9	1	3	1		1	1				7
	10	1	4			2					7
	11					1	1				2
	12	2									2
	13		1			1	1				3
Total		152	414	242	2	45	6	2	8	1	872

Table 8. Daily catches by species at the RST in the Little Main Restigouche River, 2003. Specifics of RST operations are summarized in Table 1.

Month	Day	Sea lamprey	Atlantic salmon		Speckled trout	Round whitefish	Black nose dace	White sucker	American eel	Stickleback	Slimy sculpin	Total
			Parr	Smolts								
May	6											
	7	5	17		1		1					24
	8											
	9											
	10											
	11											
	12	2	18									20
	13	1	12		1							14
	14		14									14
	15	1	13	1								15
	16	5	14	1								20
	17											
	18	3	58	8			3	1		1	1	75
	19	7	27	11			3					48
	20	4	22	4			2					32
	21	8	19	4			3					34
	22	17	14	3			1					35
	23	20	21	5	1		1					48
	24	16	12	6	1							35
	25	17	12	15		1						45
	26	15	8	11			2					36
	27											
	28	38	19	24	1		3	15				100
	29	17	10	19								46
	30	33	33	3	3							72
	31											
June	1	23	24	5			5	4				61
	2	7	14	7	2		2	1				33
	3											
	4	11	39	6			1	1				58
	5	7	5	1			3					16
	6	11	9	1			3		1			25
	7											
	8	17	71	2	1		7			2	2	102
	9	3	7	1	3		7	17				38
	10	4	16		2		3					25
	11	1	8			1	5					15
	12	4	19	4			2	1				30
	13											
	14											
	15	9	20				6	1			1	37
	16		9	1								10
	17	4	6				1					11
	18	1	6	1			3				1	12
	19											
	20											
	21		21	1			5			4	1	32
	22											
	23	14	0	2			9				1	26
	24	6	5				6			2	2	21
	25	5	0	2								7
Total		336	622	149	16	2	87	41	1	9	9	1272

Table 9. Summary of smolt sampling data from the Little Main Restigouche River RST in 2002.

Month	Day	Mortality			Released			Total
		Incidental	Tagging	Recapture	Sampled	Tagged	Recaptured	
May	8							0
	9							
	10							
	11							
	12							
	13							
	14				3			3
	15					4		4
	16					3		3
	17					1		1
	18					24		24
	19					14		14
	20					17	1	18
	21					5	3	8
	22	1	1			6		8
	23					15	2	17
	24					47	1	48
	25			1		10	3	14
	26					9		9
	27					3		3
	28					1		1
	29					16		16
	30					11	1	12
	31				1	7	1	9
June	1					19		19
	2				1	3	4	8
	3						1	1
	4							
	5							
	6							
	7						1	1
	8							
	9					1		1
	10							
	11							
	12							
	13							
Total		1	1	1	5	216	18	242

Table 10. Summary of smolt sampling data from the Little Main Restigouche River RST in 2003.

		Released			
Month	Day	Lost	Tagged	Recaptured	Total
May	6				
	7				0
	8				
	9				
	10				
	11				
	12				0
	13				0
	14				0
	15		1		1
	16		1		1
	17				
	18		8		8
	19		11		11
	20		4		4
	21		4		4
	22		3		3
	23		5		5
	24		6		6
	25	1	14		15
	26		11		11
	27				
	28		24		24
	29		18	1	19
	30		3		3
	31				
June	1		5		5
	2		6	1	7
	3				
	4		6		6
	5	1			1
	6		1		1
	7				
	8		2		2
	9		1		1
	10				0
	11				0
	12		4		4
	13				
	14				
	15				0
	16		1		1
	17				0
	18		1		1
	19				
	20				
	21		1		1
	22				
	23		2		2
	24				0
	25		2		2
Total		2	145	2	149

Table 11. Tagging, recapture and catch stratified matrix for the Little Main Restigouche River Atlantic salmon smolt production estimate, 2002. Total under recapture period excludes recaptures.

		Recapture period		
Marking period	**Tagged**	May 16-28	May 29-June13	Prop. Recaptured
May 15-27	158	11	1	0.076
May 28 - June 10	58	0	7	0.121
Total catch	216	164	59	223
				Total
Estimated run		2,232	489	2,721
(95% C.I.)				*(1,454-3,988)*
Efficiency of wheel		0.074	0.121	0.082

Table 12. Daily catches by species at the south side RST (Butters Island – NB side) in the Restigouche River, 2002. Specifics of RST operations are summarized in Table 1.

Month	Day	Sea lamprey	Gaspereau	American shad	Atlantic salmon			Speckled trout	Rainbow smelt	Common shiner	Black-nose dace	Flatfish	White sucker	American eel	Banded killifish	Stickleback	Slimy sculpin	Total
					Fry	Parr	Smolts											
May	31						229		352		2	25		36		16		666
June	1						194		128	2		34	1	36		20		415
	2					1	91		43			23		45		10		213
	3					4	86		155	1		8	1	3		18		276
	4						36		162			3		6		29		256
	5						22		100			5		16		24		167
	6			1			3		75			3		4		25		110
	7						12		13			11		17				53
	8						3		15		1	30		29		14		92
	9						4		11			14		16		3		48
	10						1		25			14		12		15		67
	11						3		15		2	15		31		26		92
	12					1	2	6	39			24	2	16		11		101
	13					1	2	4	11		20	38	2	29		19		126
	14				6		1		11		25	19	2	9	4	12		89
	15		2			1	1		5			75		13		31		126
	16								2	1		21		12		24		60
	17											11						11
	18								1			11		5		22		39
	19				3	1					1	9	1			8		23
	20										10	21		15		15		61
	21				1						3	37		6		23		70
	22				2						5	37		4	1	27		76
	23	1	1									1		3		20		24
	24											26		3		29		58
	25											28		4		20		52
	26											34		1		13		48
	27										29	1		1		33		64
	28				1							3	1	1		27	1	34
	29				1						23	3		2		75		104
	30	1									16	2		2	1	75		96
July	1	1										34		1		37		72
	2											17				75		92
	3										2	12				82		96
	4										3	15		2		97		117
	6	3			1						5	17		7		60		90
	7	1				1					4	2		3		34		44
	8				1	2					2	6		4		16		33
	9	1										8		6		21		35
	10											1		1		7		9
	11					1					5			1		25		32
	12										8	5		1		225		239
	13					1					3	6		1		28		39
	14					1					2	1		1		12		17
	15					1	1					2		2		21		27
	16											1		4		14		19
	17				12							3		1		15		31
	18													1		3		4
	19				4						1			1		8		14
	20				3							3				17		23
	21										1			1		18		20
	22							3								10		13
	23										1					78		79
	24							1			3			2		16		22
	25				92						2	1		1		10		106
	26				77						2	2				3		84
	27				80	2					6	2	1	5		21		117
	28				14	2					2		1			6		25
Total		8	3	1	298	20	691	14	1183	4	189	730	12	423	6	1645	1	5216

Table 13. Daily catches by species at the north side RST (Moses Island – Quebec side) in the Restigouche River, 2002. Specifics of RST operations are summarized in Table 1.

Month	Day	Atlantic salmon			Speckled trout	Rainbow smelt	Black-nose dace	Fallfish	American eel	Banded killifish	Stickleback	Total
		Fry	Parr	Smolts								
May	31			16		7			5			28
June	1			15		13						28
	2			33		91		1	2		2	129
	3		1	15		15			1		1	33
	4			3		65						68
	5		1	1		9			1		1	13
	6		1	1		16			1			19
	7					4					2	6
	8					3			5			8
	9					5			1			6
	10			1		1						2
	11			1		6			3		2	12
	12					6			2		2	10
	13				6	4			3	1	2	16
	14	50	1						1			52
	15							20	1		1	22
	16					1			1			2
	17						1	51			1	53
	18							35	1		1	37
	19	26	1				1		1			29
	20	12							4		2	18
Total		88	5	86	6	246	2	107	33	1	17	591

Table 14. Daily catches by species at the north side RST (Moses Island – Quebec side) in the Restigouche River, 2003. Specifics of RST operations are summarized in Table 1.

Month	Day	Lamprey	Gaspereau	Atlantic salmon			Speckled trout	Rainbow smelt	Shiner	Blank nose dace	Fallfish (chub)	White sucker	American eel	Banded killifish	Stickleback	Slimy sculpin	Total
				Fry	Parr	Smolts											
May	14																
	15																
	16				26	4							1				31
	17				30	4		4				5			1		44
	18	1			22	19				1	1	7	3		6		60
	19				24	47		2				17			20		110
	20	1			13	13					1	5			5		38
	21				15	58		1				20	1		2		97
	22				15	94						14	1		4		128
	23	2			5	81					1	4			1		94
	24				20	95		2				4	2		1		124
	25				5	189				2		24	2		6		228
	26				12	165				1		1	2	1	1		183
	27				9	224		1				6	2		7		249
	28				4	183					1	13			5		206
	29				3	288		4			7	82	3		30		417
	30	1			10	263		4				19	1		21		319
	31				10	261		43				15	1		9		339
June	1				10	264		5		1		34	3		14		331
	2	1			5	101					1	13	5		7		133
	3	1			17	120		6			10	4	4		7		169
	4				14	119		9		1		9			8		160
	5				9	96		7				67	6	1	13		199
	6	1			10	24				1	3	129	5		10		183
	7				12	31		18		9	9	111	10		10		210
	8				11	20				3	8	71	14		22		149
	9	1			12	14		6				11	6		10		60
	10				7	4		1		2		6	4		26		50
	11	1			9	7		1			10	15	4		13		60
	12				8	12		2			1	4	1		21		49
	13				14	5		2			5	13	8		13		60
	14				5	5					8	24	6		42		90
	15			1	2	1					3	13	7	1	34		62
	16			10	2	1					3		3		30		49
	17			12	5	2			1	2	14	12	6		39		93
	18			68	4	1				1	1	50	13		44		182
	19			69	5	3				2	6	15	7		54		161
	20			243	1			2		3	3	7	6		67		332
	21	1		148	7			1			21	5	6	1	66		256
	22			63	2			1	1	1	12	7	4		83		174
	23		2	25						1	8	2	6		83		127
Total		11	2	639	394	2818	0	122	2	31	137	858	153	4	835	0	6006

Table 15. Daily catches by species at the south side RST (Butters Island – NB side) in the Restigouche River, 2003. Specifics of RST operations are summarized in Table 1.

Month	Day	Lamprey	Gaspereau	Atlantic salmon			Speckled trout	Rainbow smelt	Shiner	Black nose dace	Fallfish (chub)	White sucker	American eel	Banded killifish	Stickleback	Slimy sculpin	Total
				Fry	Parr	Smolts											
May	14				4	1					1						6
	15	1			8	3					2		1				15
	16	1			9	5											15
	17				28	3		1			1				1		34
	18	1			53	6						12	3		6		81
	19	1			35	20		6			1	29	2		2		96
	20				29	39		6				43	4		8		129
	21	1			9	61		19			5	54	2		13		164
	22	1			15	86		8				17	2		5		134
	23	1			10	68		27		3	5	12			12		138
	24				7	77		84		3		5	2	1	23		202
	25	1			11	74		166		5	2	21	4	1	44		329
	26	1			9	92		120		6	1	28	1		107		365
	27	4			2	13		7				7	2		126		161
	28				2	155		142		4	10	49	9		83		454
	29					107		92			33	39	9		85		365
	30				3	90		58			6	14	1		46		221
	31					68		27			21	130	3		48		297
June	1				3	77		51	1		4	24	12		41		213
	2				3	5		2			3		4		5		22
	3				4	162		38		1	37	7	4		24		277
	4				11	62		83			4	16	3		20		199
	5				3	37		36			29	12	10		18		145
	6					14		27			37	36	20		26		160
	7				4	33		15		1	46	59	15		29	1	203
	8				2	34				4	105	44	14		31		234
	9	1			7	9					60	7	8		19		111
	10				2	1				1	39	5	4		9		61
	11	1				4				3	34	5	8		30		85
	12				1					2	18	2			21		44
	13		1		1		1			1	23	1			6		34
	14				1	1		1		7	60	9	3	3			85
	15				1					1	23	6	1		20		52
	16					1				5	16	1	1		27		51
	17				1	1				2	36	8	6		41		97
	18			4	1			1	1	3	49	11	7	2	33		112
	19			3	2					6	84	14	5		52		166
	20	1		5				1		3	41	7	6	1	68		133
	21			3	1					4	34	2	3	1	55		103
	22			3							61	4	2		36		106
	23									1	27	3	3		64		98
Total		16	1	18	282	1409	1	1018	2	66	963	743	184	9	1264	1	5997

Table 16. Summary of smolt sampling data from the south side RST (Butters Island) in 2003.

South side RST (Butters Island) - 2003

		Mortality		Released		Tagged		Recaptures from RST				
						released at		south side RST released		north side RST		
Month	Day	Incidental	Sacrificed	Released	Sampled	south side	north side	south side	north side	north side	Kedgwick	Total
May	14				1							1
	15				3							3
	16					5						5
	17	1					2					3
	18					6						6
	19						20					20
	20		5			34						39
	21		5				56					61
	22		5			81						86
	23		5				63					68
	24		5			71				1		77
	25		5				69					74
	26		5			87						92
	27	6					7					13
	28		5			150						155
	29		5				101				1	107
	30		5			84		1				90
	31		5				62	1				68
June	1		5			72						77
	2						5					5
	3		5	132	24			1				162
	4		5	32	25							62
	5		5	7	25							37
	6					14						14
	7		5				27				1	33
	8		5			29						34
	9						9					9
	10					1						1
	11						4					4
	14					1						1
	16					1						1
	17						1					1
Total		7	85	171	78	636	426	3		1	2	1409

Table 17. Summary of smolt sampling data from the north side RST (Moses Island) in 2003.

North side RST (Moses Island) - 2003

Month	Day	Mortality		Released		Tagged		Recaptures from RST					Total
						released at		south side RST released		north side RST			
		Incidental	Sacrificed	Released	Sampled	south side	north side	south side	north side	north side	Kedgwick	Little Main	
May	16						4						4
	17						4						4
	18		5				14						19
	19		5				42						47
	20						13						13
	21						58						58
	22	3					91						94
	23						81						81
	24						95						95
	25						189						189
	26						164					1	165
	27		5				219						224
	28	1					182						183
	29						287					1	288
	30						260					3	263
	31			160			101						261
June	1			157			100			1	1	4	264
	2		5	70	2		23					1	101
	3			118								2	120
	4			118								1	119
	5			92								4	96
	6		5				19						24
	7						31						31
	8						20						20
	9						14						14
	10						4						4
	11						7						7
	12						11			1			12
	13						5						5
	14						4			1			5
	15						1						1
	16						1						1
	17						2						2
	18						1						1
	19						3						3
Total		4	25	715	2		2050		1	3	17	1	2818

Table 18. Days to recapture of smolts released from the Restigouche River RSTs in 2002 and 2003.

2002			Number recaptured at		
RST location	Release location	Days to recapture	Recycled	Restigouche south side	Restigouche north side
Kedgwick	Kedgwick	1	3		
		4	1		
Little Main	Little Main	1	17		
		3	1		
		15	1		

2003			Number recaptured at		
RST location	Release location	Days to recapture	Recycled	Restigouche south side	Restigouche north side
Kedgwick	Kedgwick	1	39		
		2	5		
		3	1		7
		4		2	6
		5	1		2
		6			2
		7			
		9	1		
Little Main	Little Main	1	2		
		4			1
Restigouche north side	North side	1			3
		2		1	
Restigouche south side	South side	2		2	
		3		1	
	North side	1			1

Table 19. Among tributary and main river comparison of Atlantic salmon smolt characteristics and relative species abundance.

	Kedgwick		Little Main		Restigouche 2002		Restigouche 2003	
	2002	2003	2002	2003	North	South	North	South
Smolt run-timing (date)								
First smolt	10 May	10 May	*14 May*[†]	15 May	-	-	*16 May*[†]	*14 May*[†]
Peak	24, 31 May	29 May	24 May	28 May	-	-	29 May	28 May, 3 June
Median	29 May	28 May	24 May	28 May	-	-	29 May	28 May
Last smolt	12 June	*19 June*[†]	9 June	*25 June*[†]	11 June	15 June	19 June	17 June
Smolt production per 100 m^2 (median and 95% C.I.)	-	4.0 (2.4 – 5.6)	0.2 (0.1 – 0.4)	-	-		1.4 (0.9 – 2.2)	
Fork length (cm)								
Median	12.5	13.0	13.0	13.5	12.5		12.5	
	2002 < 2003		same			same		
2002	Kedgwick = Restigouche < Little Main							
2003	Restigouche < Kedgwick < Little Main							
Condition								
	2002 < 2003		-			-		
2003	Kedgwick < Restigouche							
Proportion female	0.54	0.44	-	-	-		0.32	
Parr adundance relative to smolts (% by number)	106	175	171	417	6	3	14	20
Lamprey abundance relative to smolts (% by number)	5	44	63	226	0	1	<1	1
Eel abundance relative to smolt (% by number)	6	8	0	1	38	61	5	13
Salmon abundance (% by number of total catch of all fish)	92	82	75	61	30	20	64	30

[†] first date or last date of operation

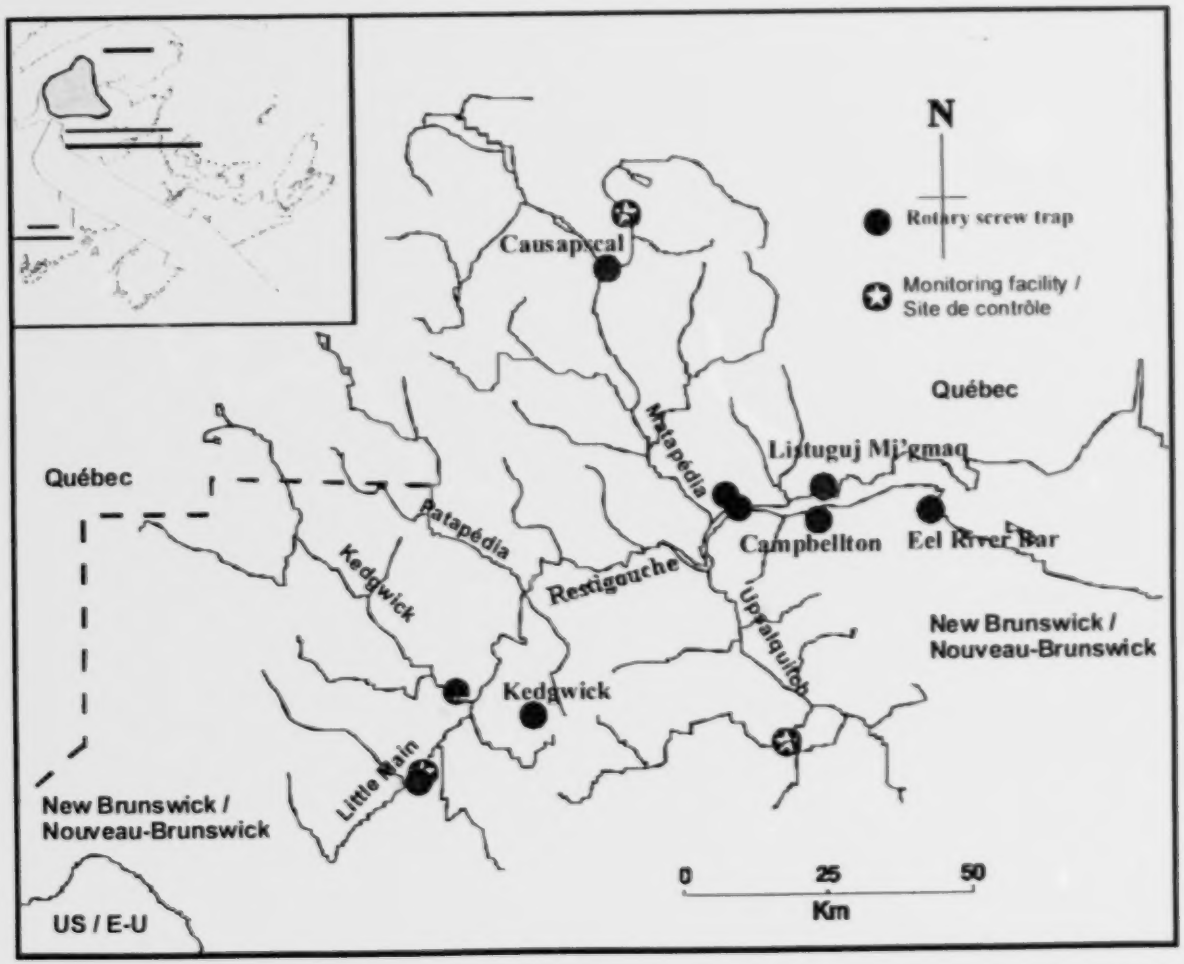


Figure 1. Map of Restigouche River showing tributaries and location of rotary screw traps (RSTs) in 2002 and 2003.

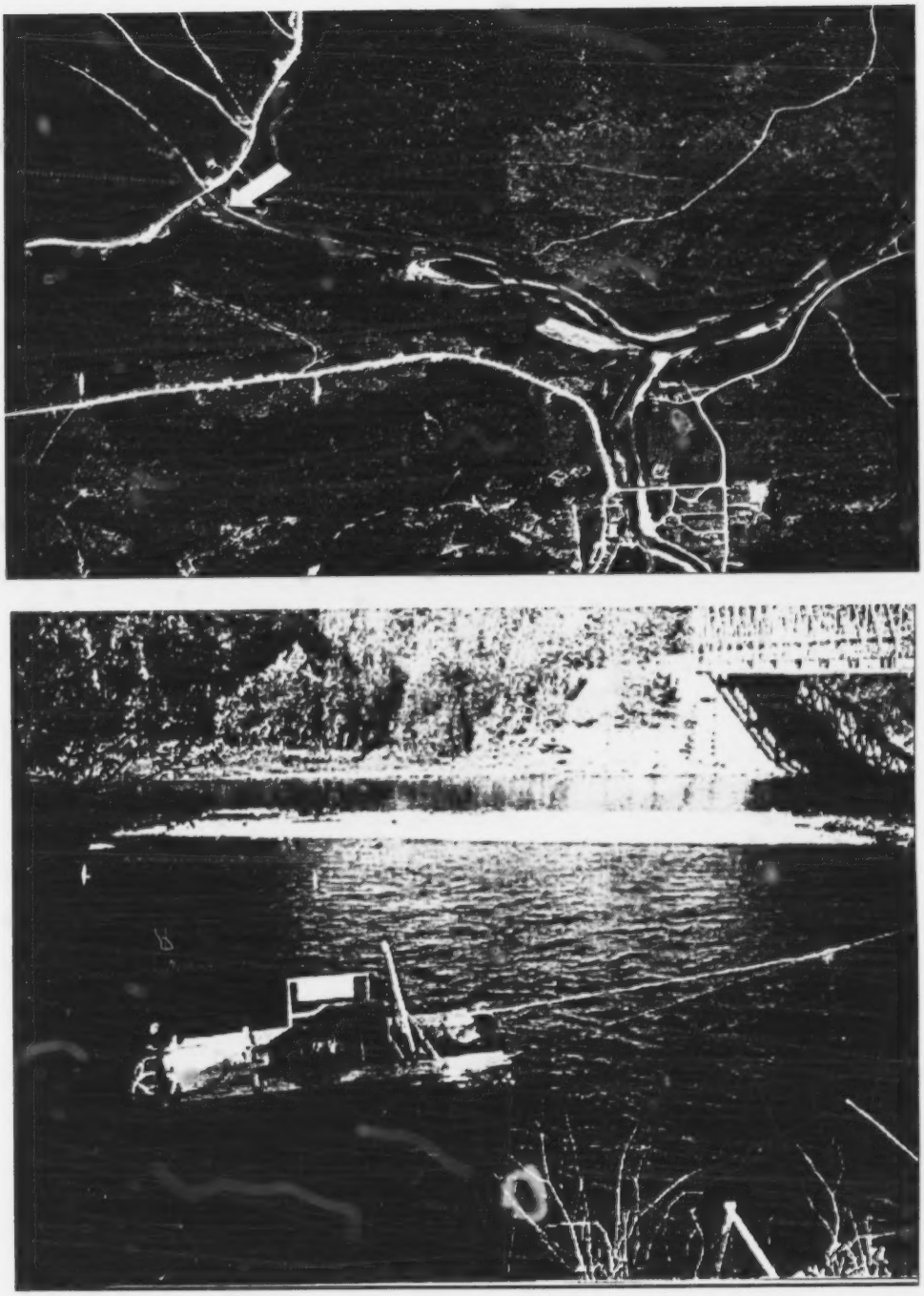


Figure 2. Location of Kedgwick River RST (arrow in upper) and channel configuration at low water (lower).

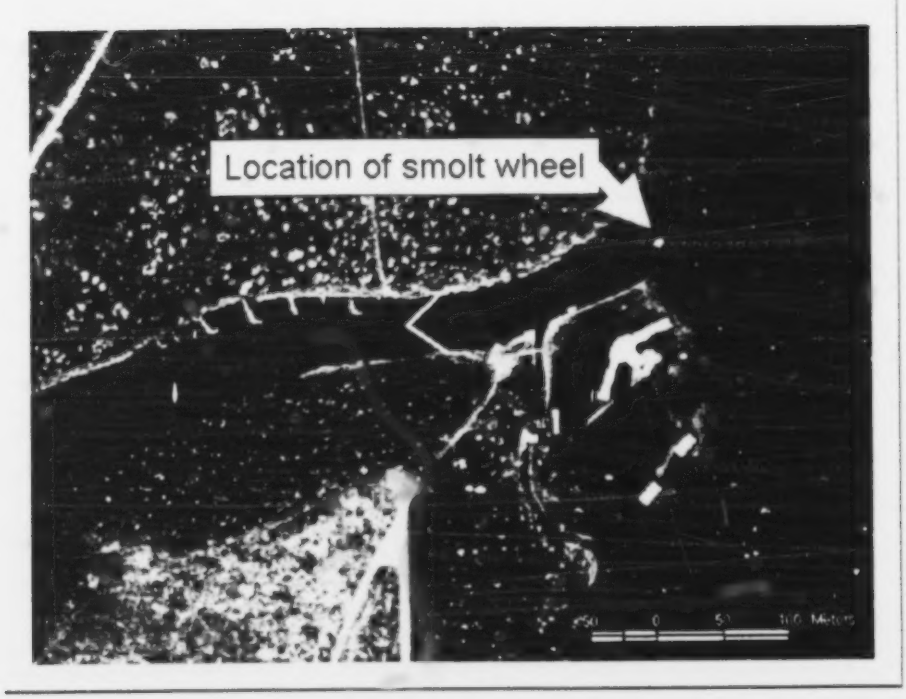


Figure 3. Location of Little Main Restigouche River RST.

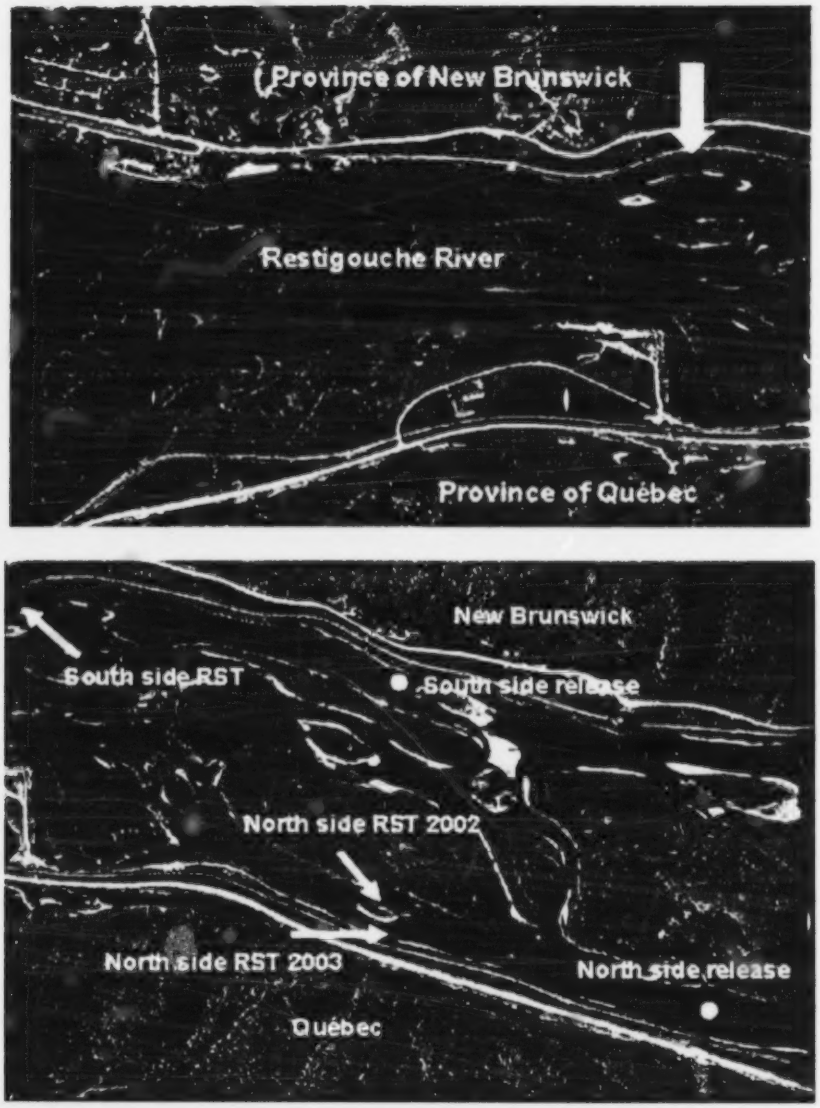


Figure 4. Location of the lower river Restigouche RSTs showing placement of south side RST (upper panel white arrow) and the north side RST and release sites (lower panel).

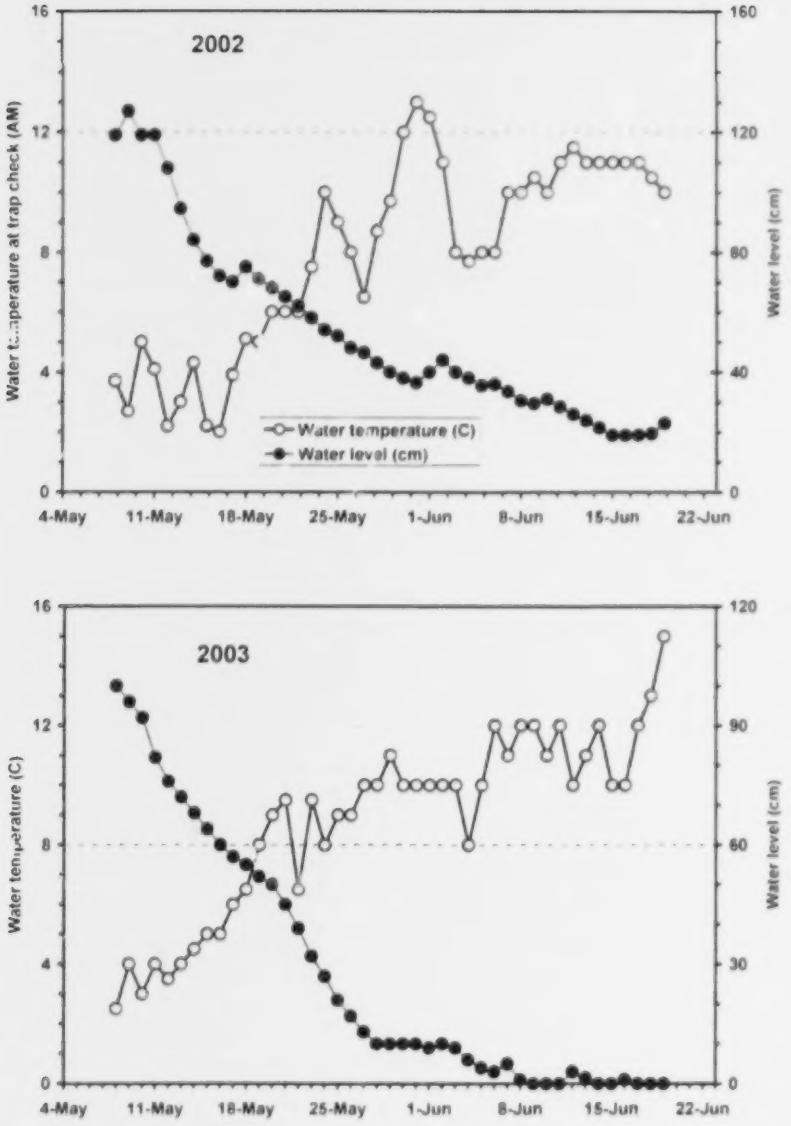


Figure 5. Environmental conditions at the Kedgwick River RST in 2002 (upper) and 2003 (lower).

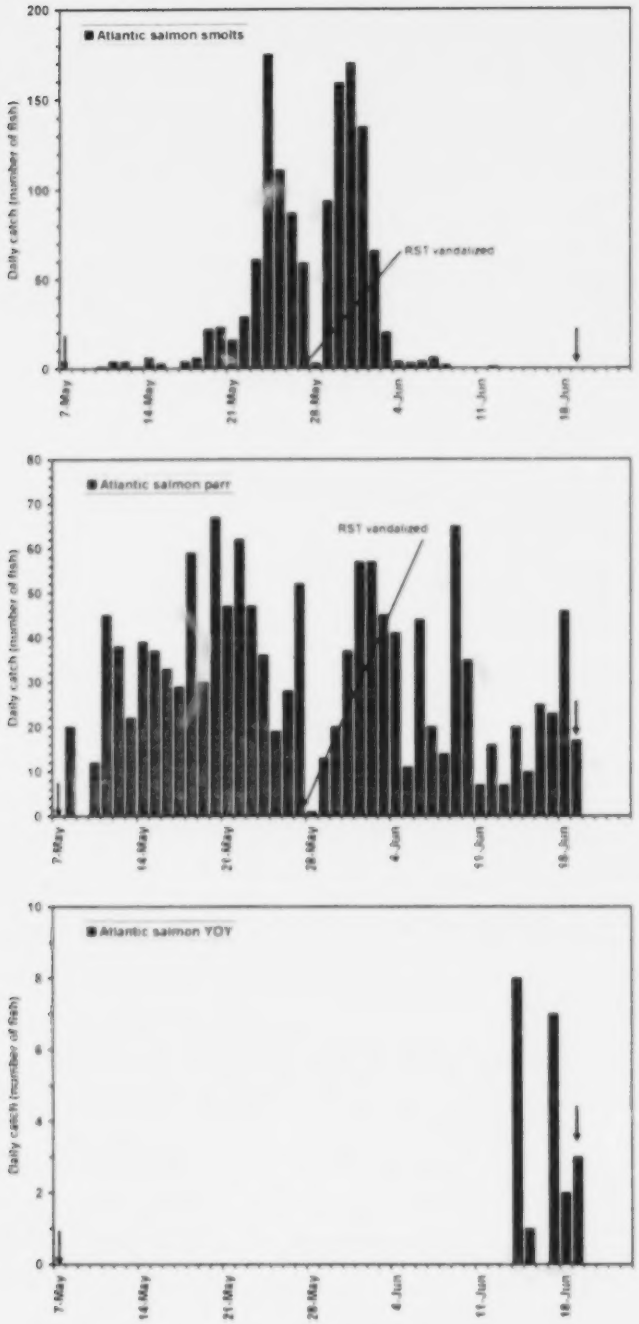


Figure 6. Catches of Atlantic salmon smolts (upper), salmon parr (middle) and salmon emergent fry (lower) at the Kedgwick RST in 2002. Solid vertical arrows indicate the start and finish dates of operation in 2002.

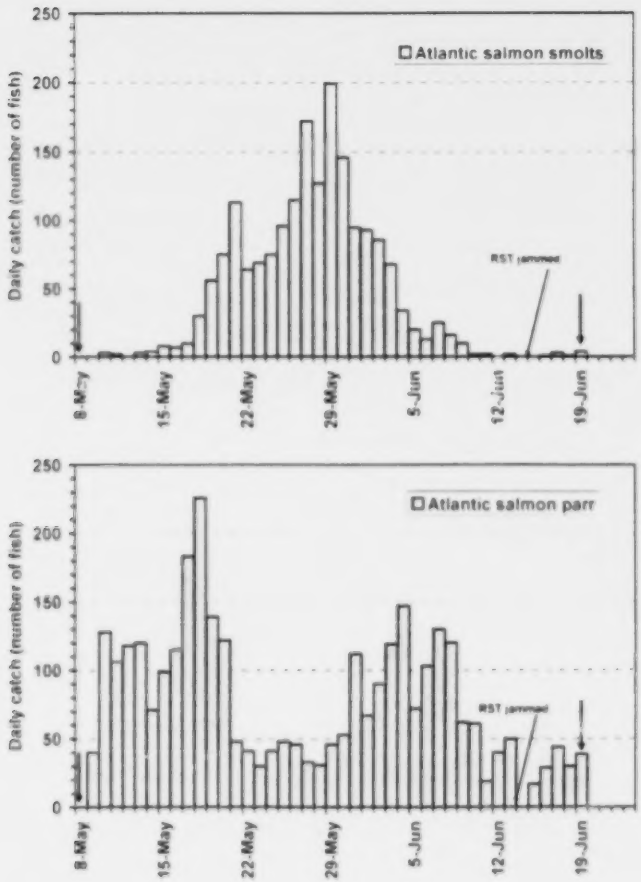


Figure 7. Catches of Atlantic salmon smolts (upper) and salmon parr (lower) at the Kedgwick RST in 2003. Solid vertical arrows indicate the start and finish dates of operation in 2003.

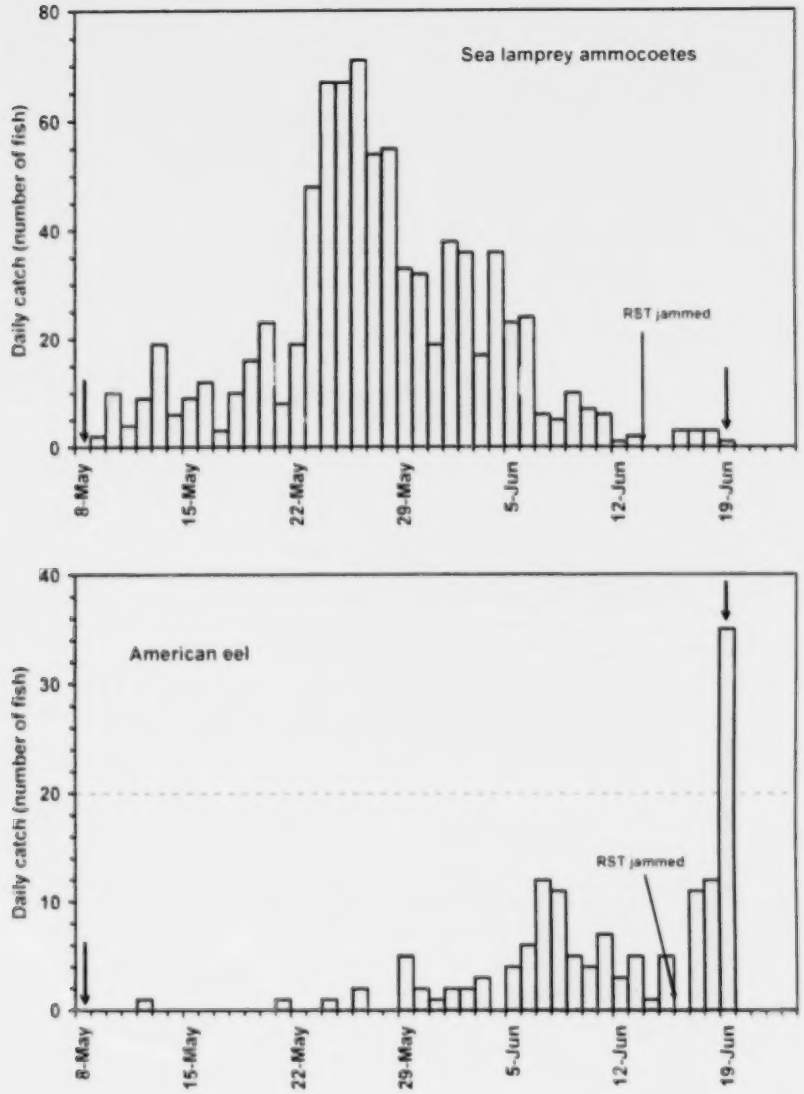


Figure 8. Catches of sea lamprey ammocoetes (upper) and American eel (lower) at the Kedgwick RST in 2003. Solid vertical arrows indicate the start and finish dates of operation in 2003.

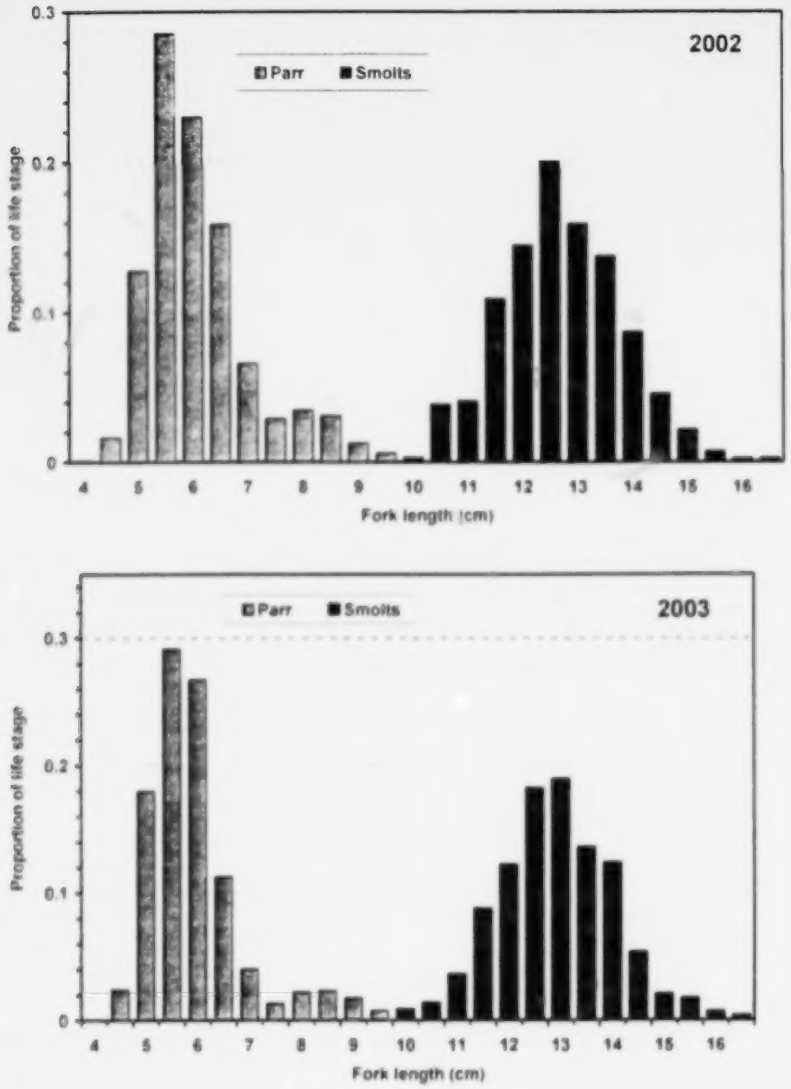


Figure 9. Fork length distributions of Atlantic salmon parr and smolts sampled from the Kedgwick River RST in 2002 (upper) and 2003 (lower).

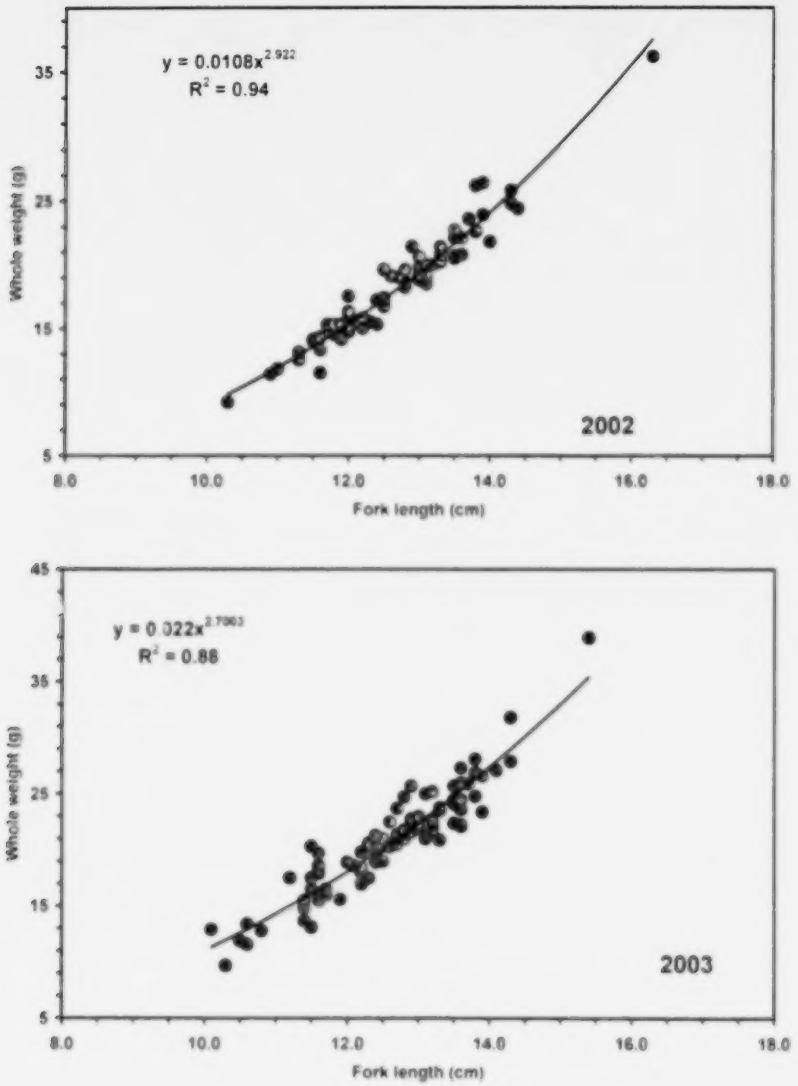


Figure 10. Length-weight relationships of Atlantic salmon smolts from the Kedgwick River in 2002 (upper) and 2003 (lower).

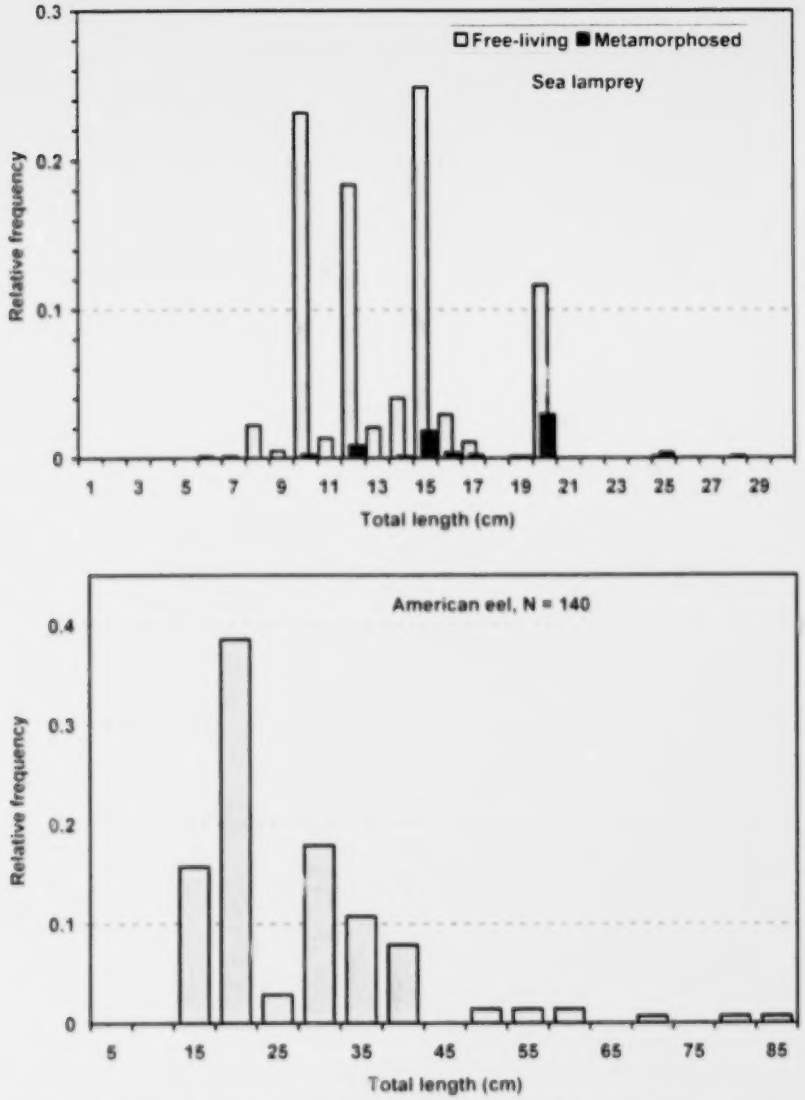


Figure 11. Relative frequency total length distributions of sea lamprey (upper) and American eel (lower) sampled from the Kedgwick River RST in 2003.

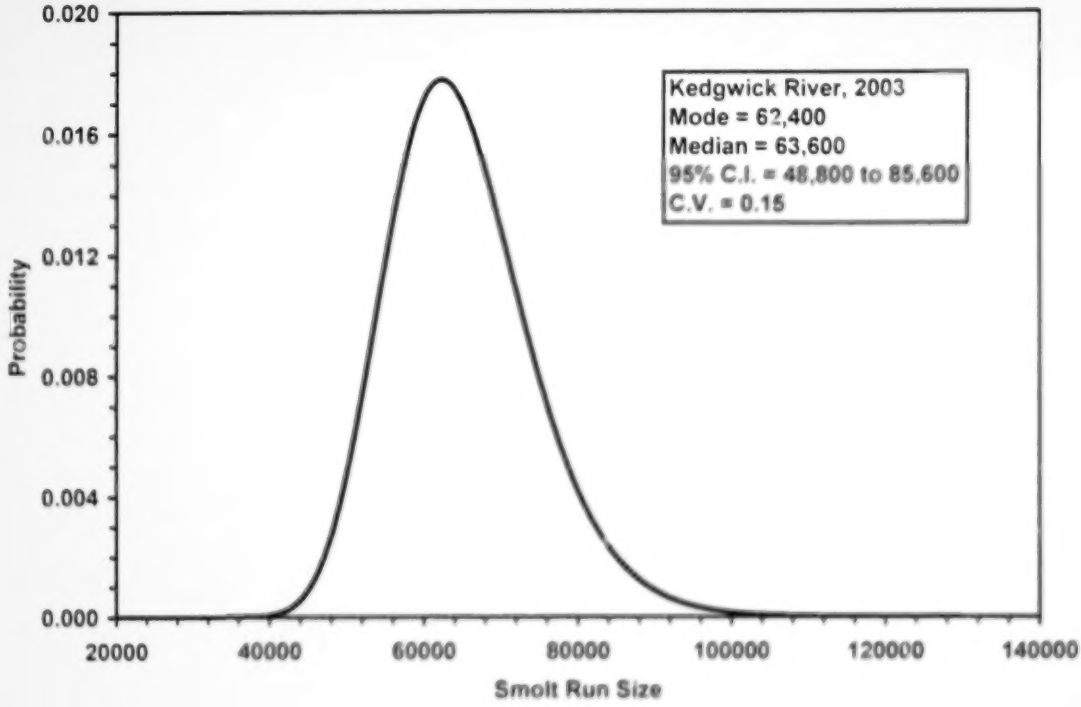


Figure 12. Bayes (Gazey and Staley 1986) estimate of run size of Atlantic salmon smolts from the Kedgwick River in 2003. Input parameters for the estimates were: M = 1,696, R = 49, C(U) = 1,800.

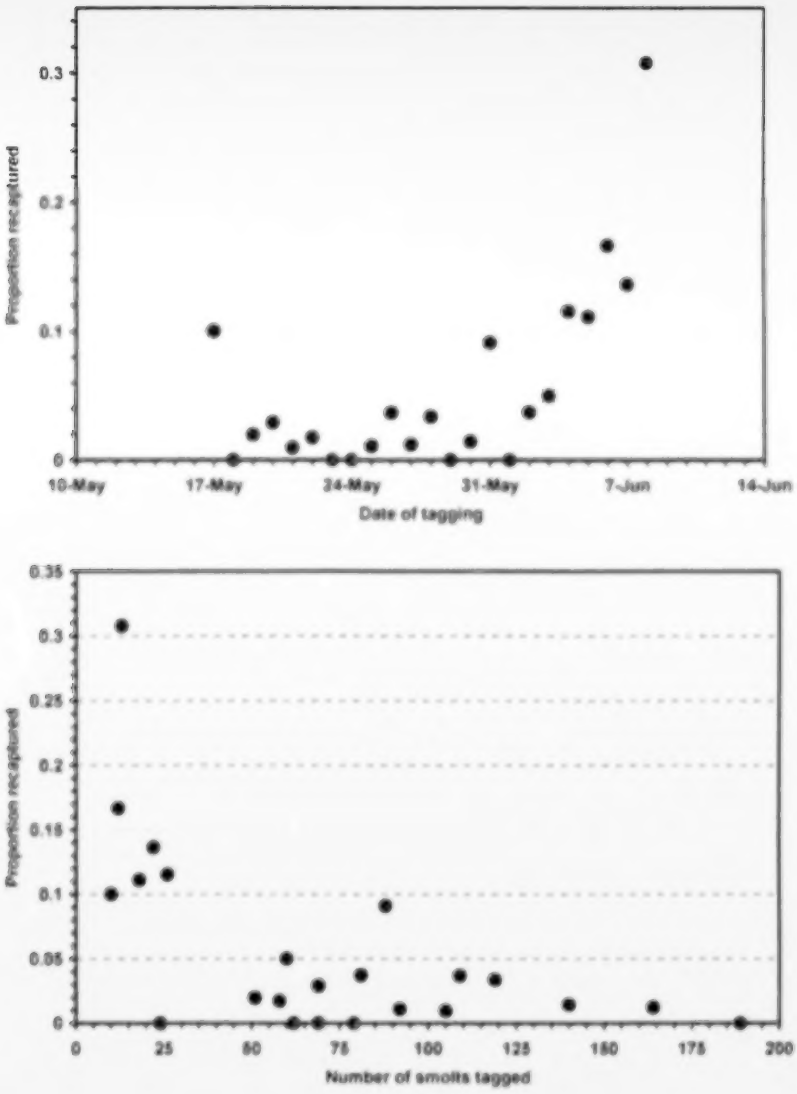


Figure 13. Proportion of tagged fish recaptured at the Kedgwick RST in 2003 relative to date of tagging (upper) and number of smolts tagged (lower). Only tagging groups with at least 10 smolts tagged and released are shown.

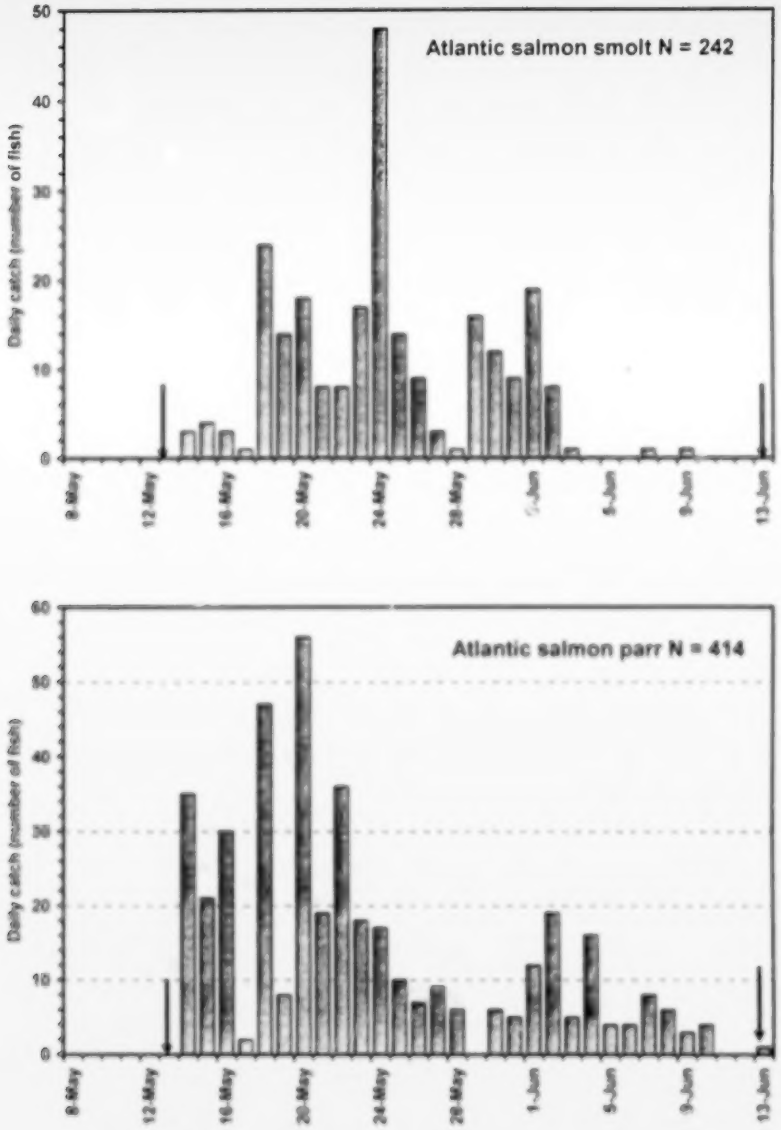


Figure 14. Catches of Atlantic salmon smolts (upper) and salmon parr (lower) at the Little Main Restigouche River RST in 2002. Solid vertical arrows indicate the start and finish dates of operation in 2002.

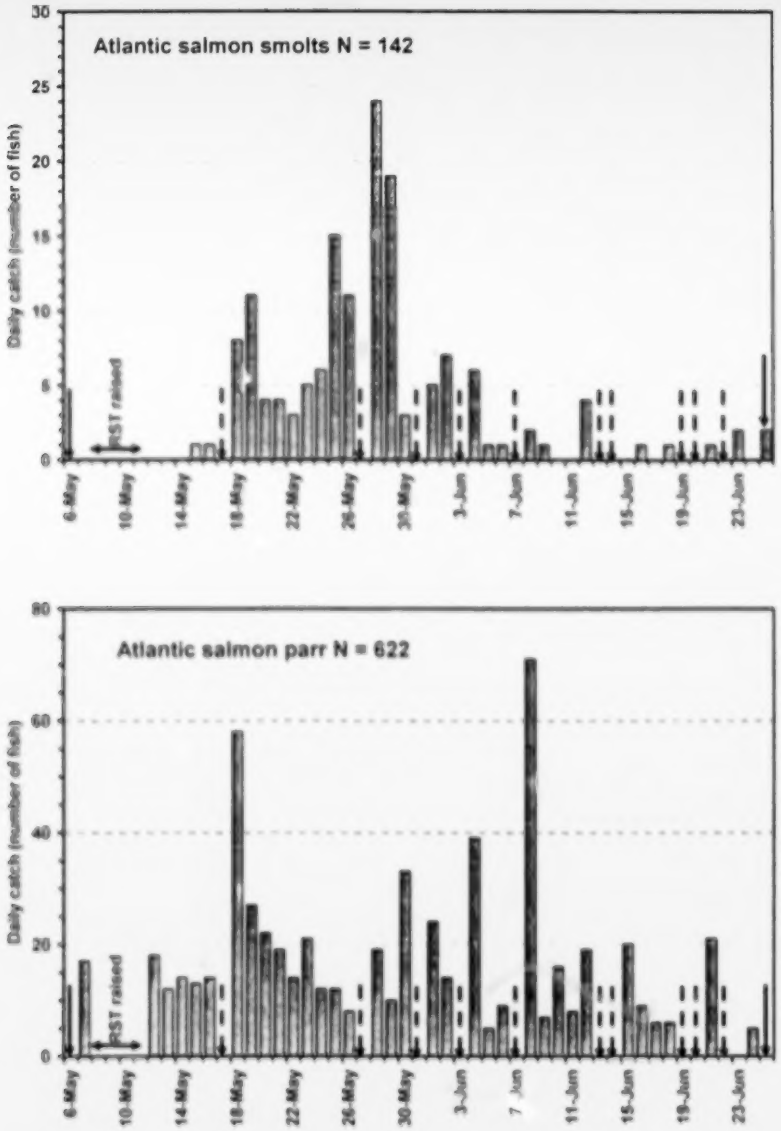


Figure 15. Catches of Atlantic salmon smolts (upper) and salmon parr (lower) at the Little Main Restigouche River RST in 2003. Solid vertical arrows indicate the start and finish dates of operation in 2003. Dashed arrows indicate RST was operating but fish not processed.

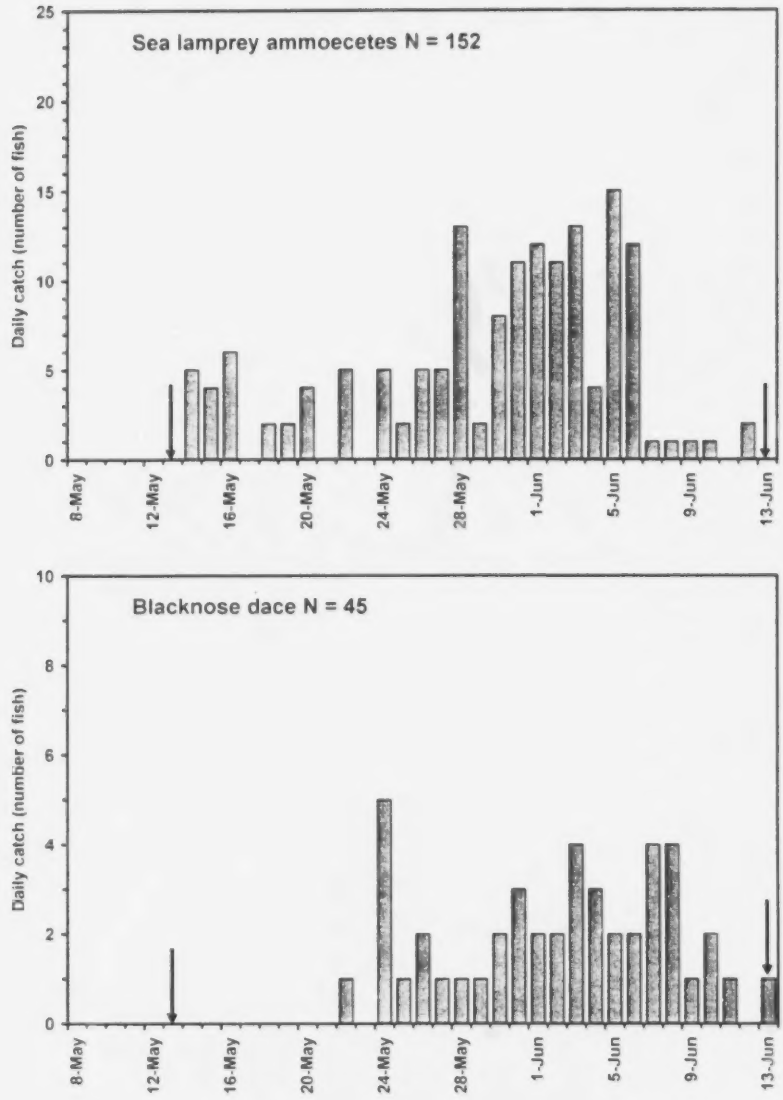


Figure 16. Catches of sea lamprey ammoecetes (upper) and blacknose dace (lower) at the Little Main Restigouche River RST in 2002. Solid vertical arrows indicate the start and finish dates of operation in 2002.

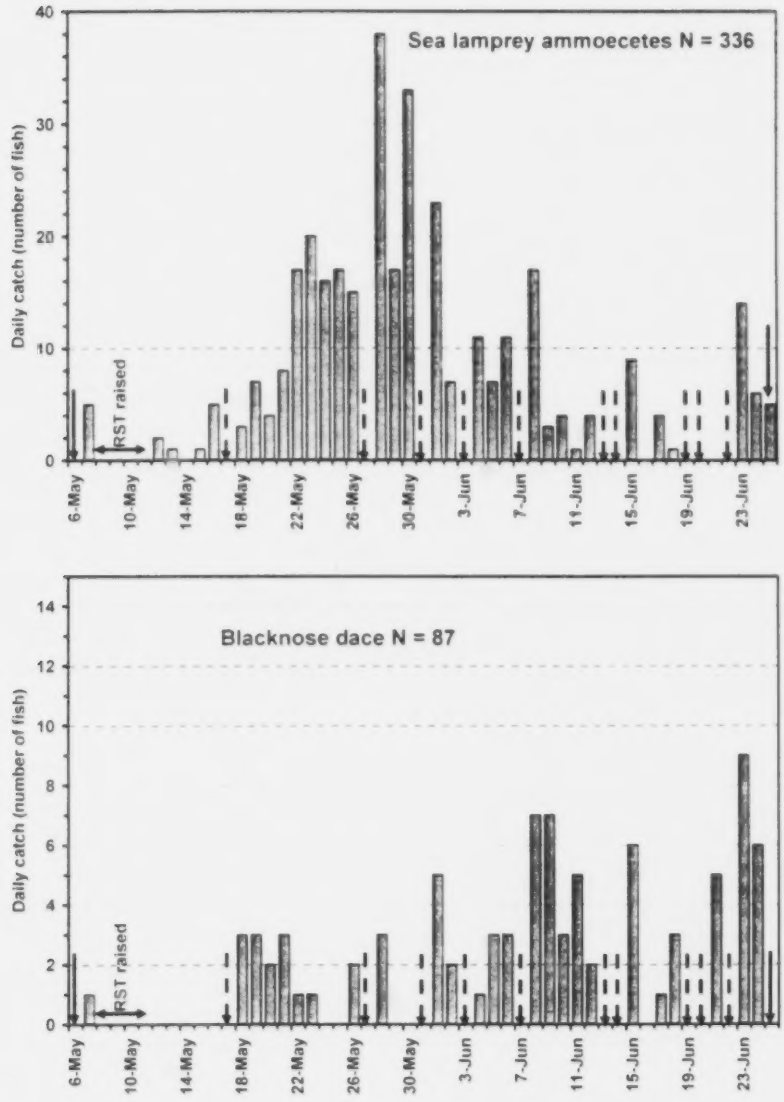


Figure 17. Catches of sea lamprey ammoecetes (upper) and blacknose dace (lower) at the Little Main Restigouche River RST in 2003. Solid vertical arrows indicate the start and finish dates of operation in 2003. Dashed arrows indicate RST was operating but fish not processed.

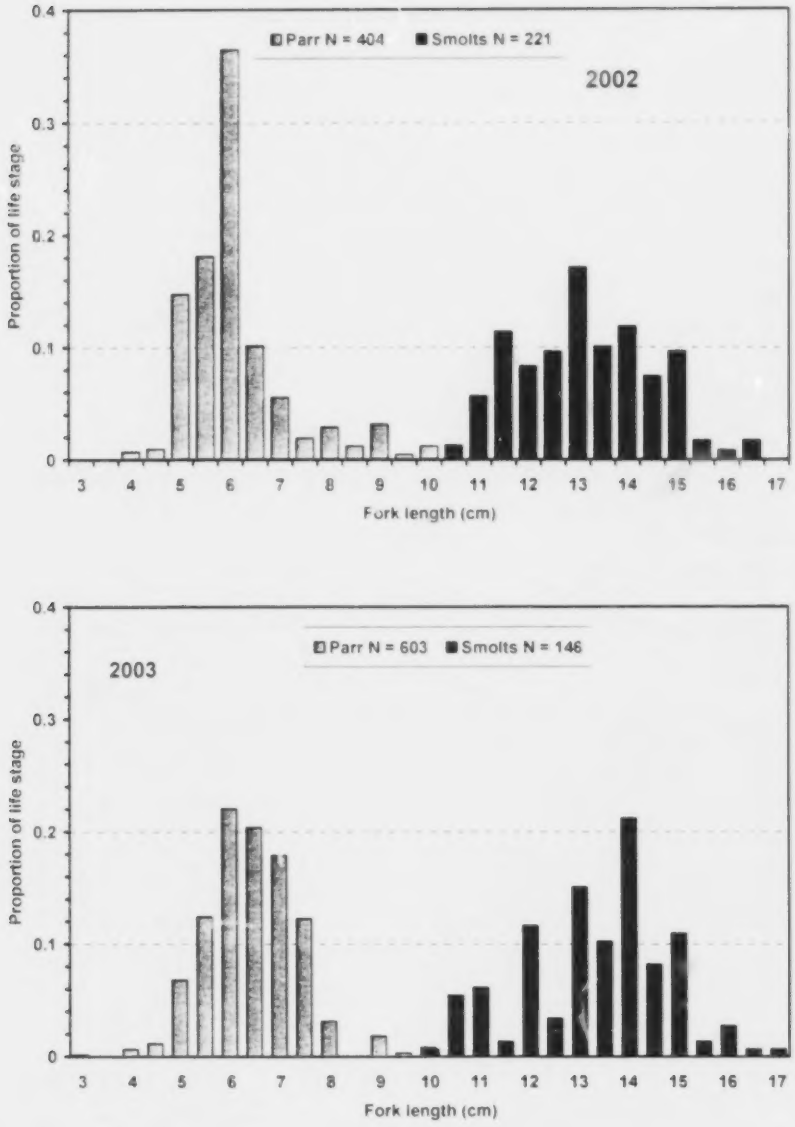


Figure 18. Fork length distributions of wild origin Atlantic salmon parr and smolts sampled from the Little Main Restigouche River RST in 2002 (upper) and 2003 (lower).

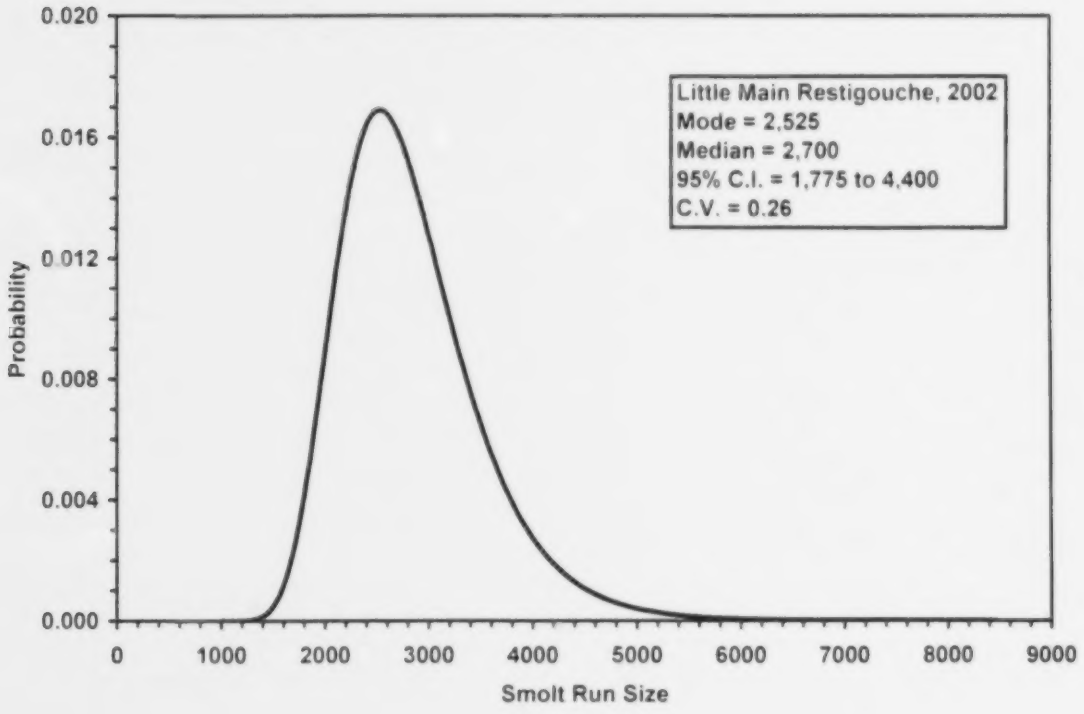


Figure 19. Bayes (Gazey and Staley 1986) estimate of run size of Atlantic salmon smolts from the Little Main Restigouche River portion above Boston Brook in spring 2002. Input parameters for the estimates were: M = 216, R = 19, C(U) = 223.

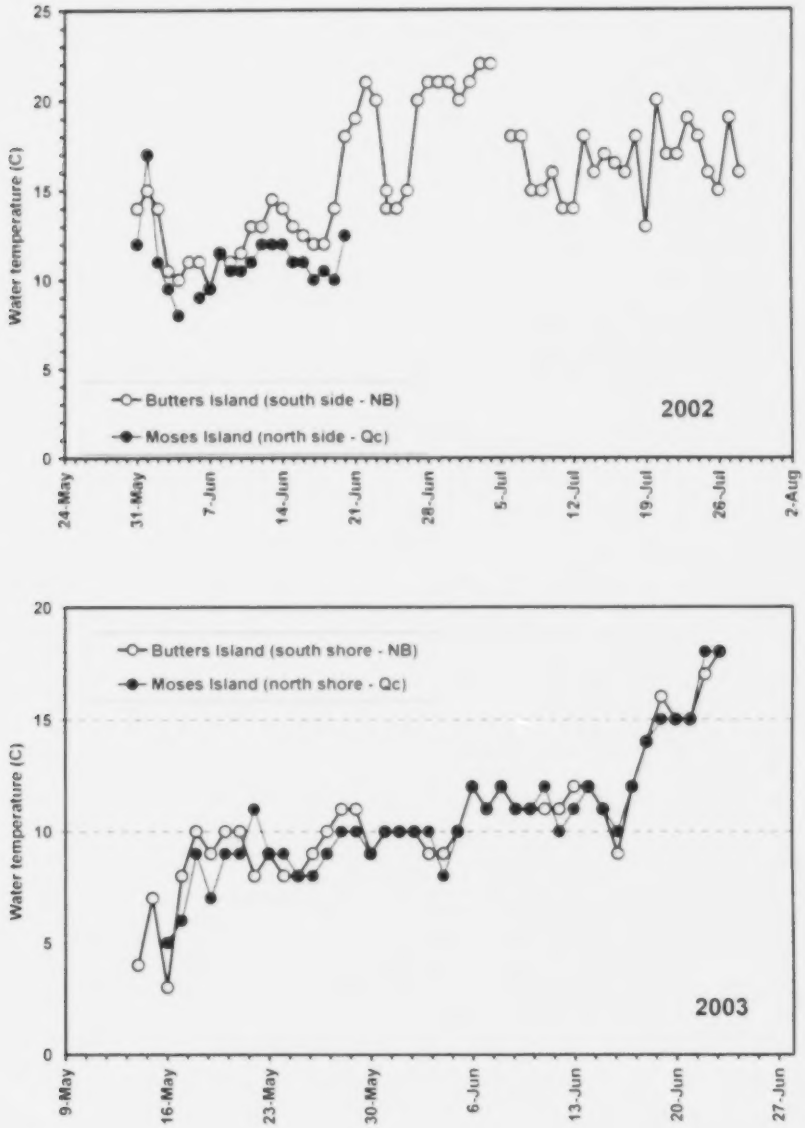


Figure 20. Water temperature (°C) at time of fish sampling (AM) at the Restigouche River RSTs in 2002 (upper) and 2003 (lower).

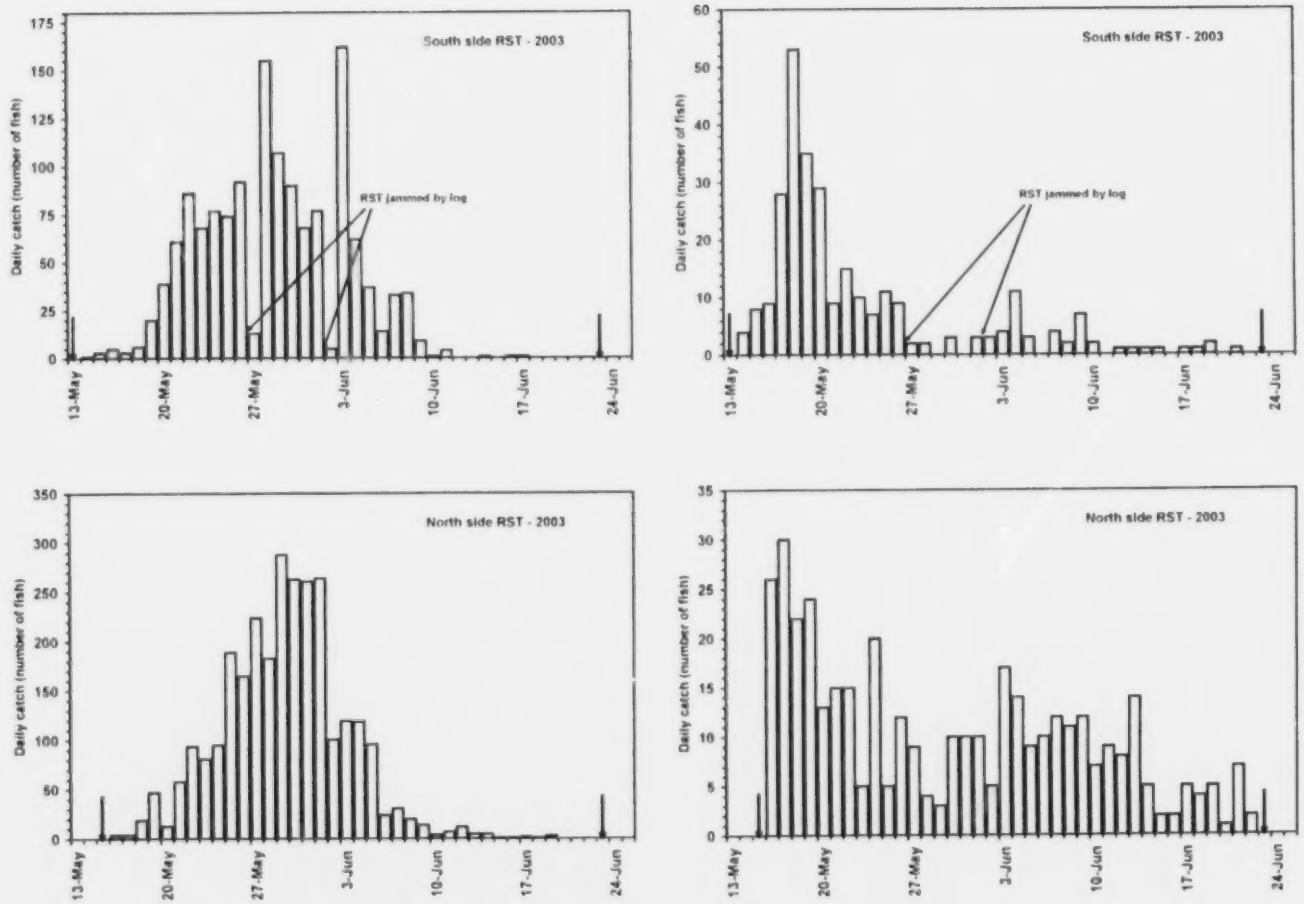


Figure 21.Daily catch of Atlantic salmon smolts (left panels) and parr (right panels) from the south side RST (upper panel) and the north side RST (lower panels) in the Restigouche River, 2003. Solid vertical arrows indicate the start and finish dates of operation in 2003.

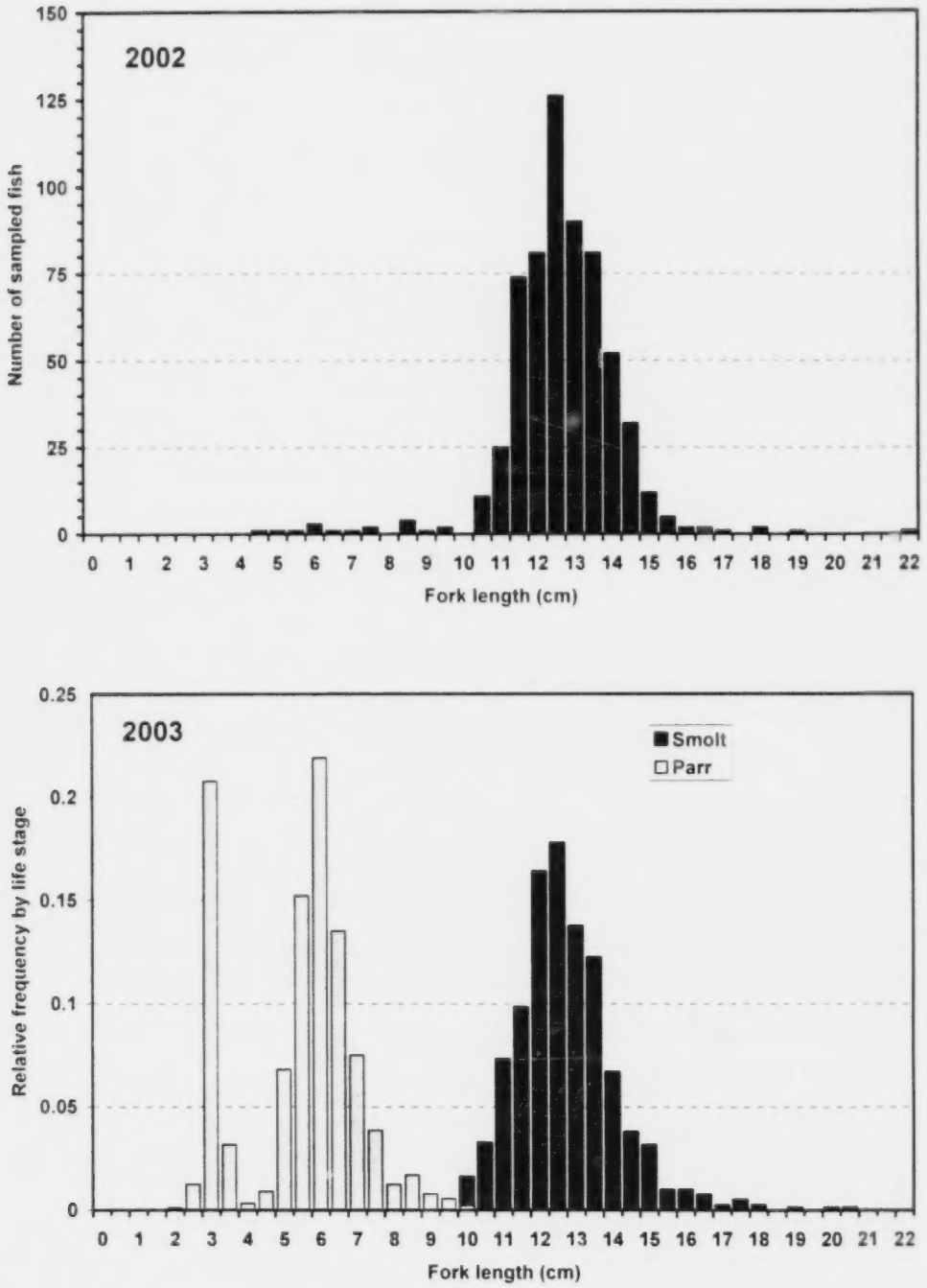


Figure 22. Fork length (by 0.5 cm group) of Atlantic salmon parr and smolts sampled from the RSTs in the the lower Restigouche River in 2002 (upper) and 2003 (lower).

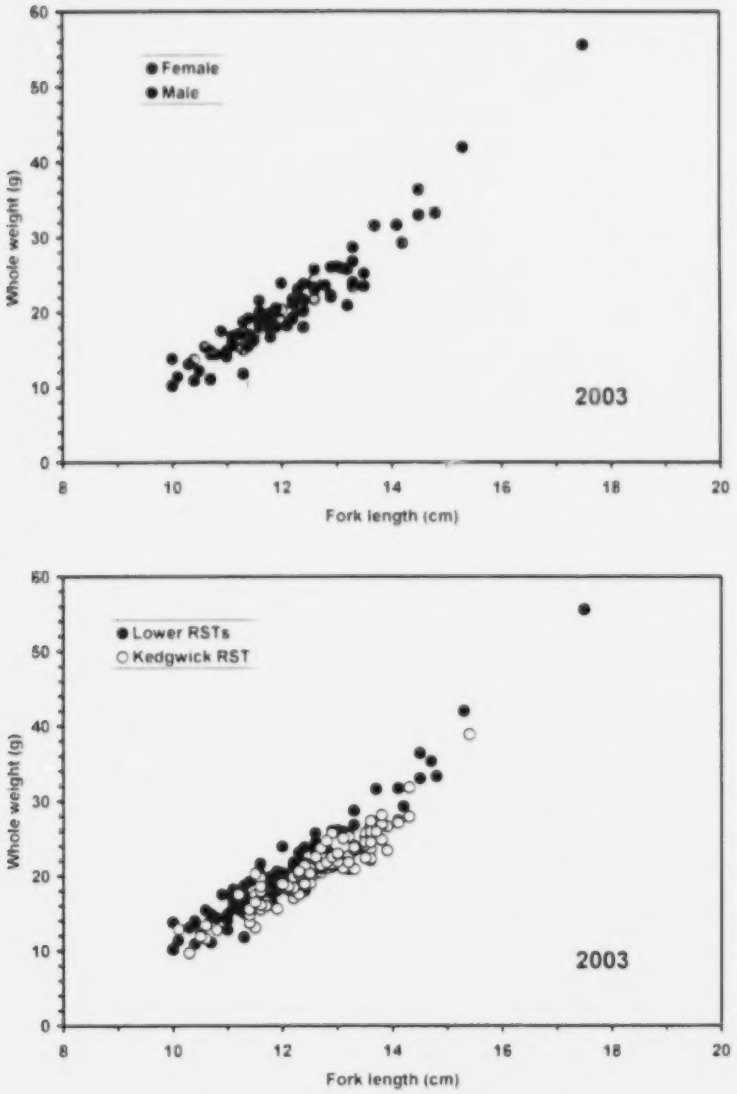


Figure 23. Length-weight relationship of male and female Atlantic salmon smolts from the lower Restigouche River RSTs in 2003 (upper) and comparison with smolts from Kedgwick River RST in 2003 (lower).

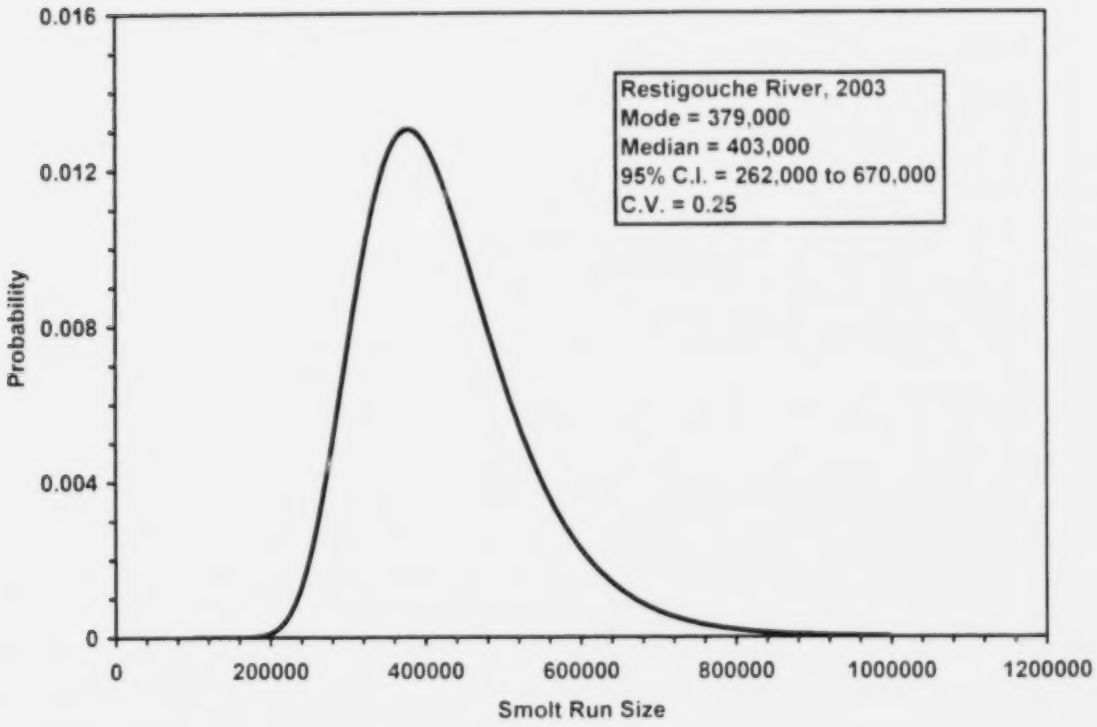


Figure 24. Bayes (Gazey and Staley 1986) estimate of run size of Atlantic salmon smolts from the Restigouche River in 2003. Input parameters for the estimates were: M = 1,704, R = 19, C(U+R) = 4,219.

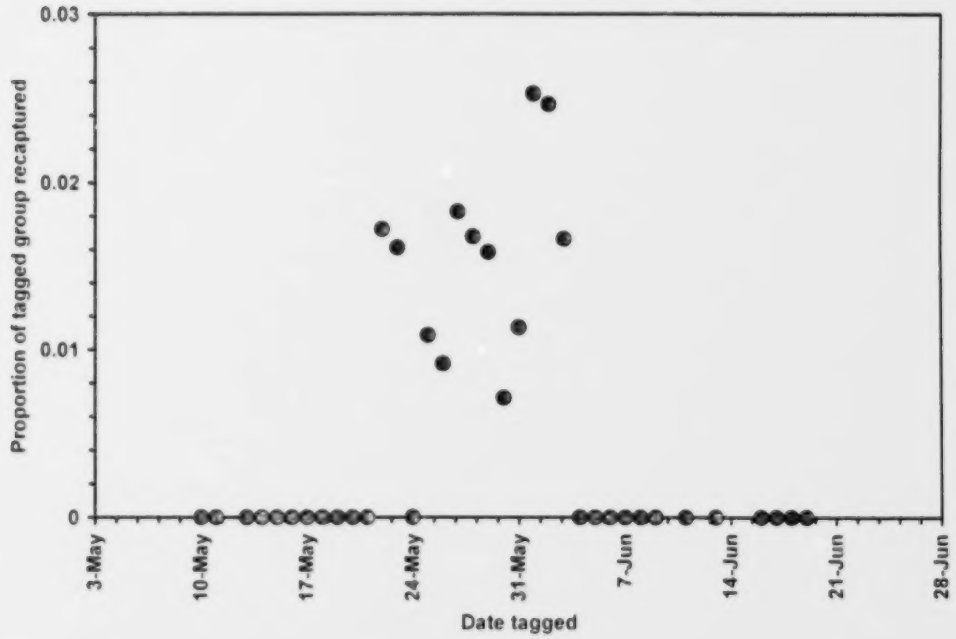
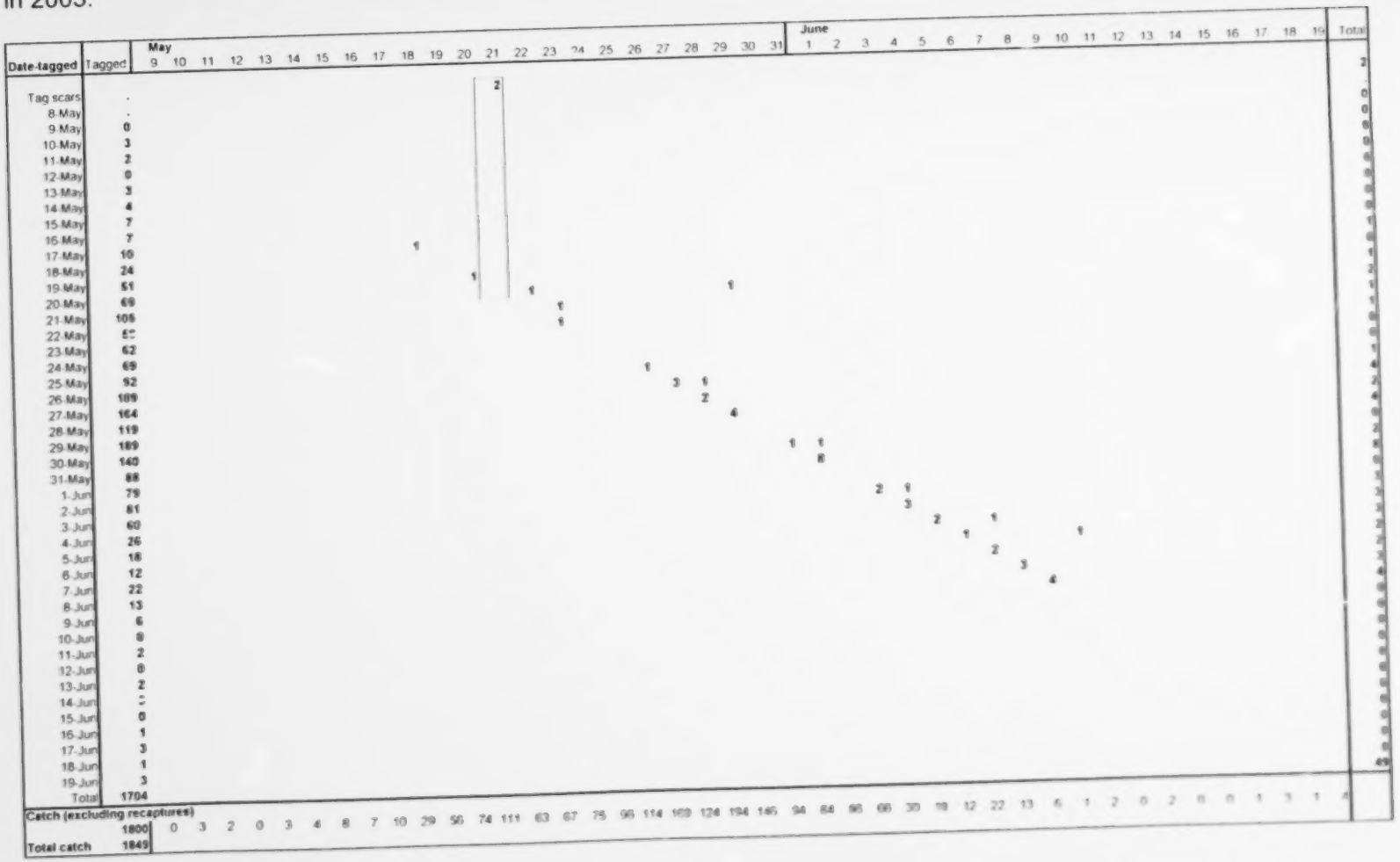
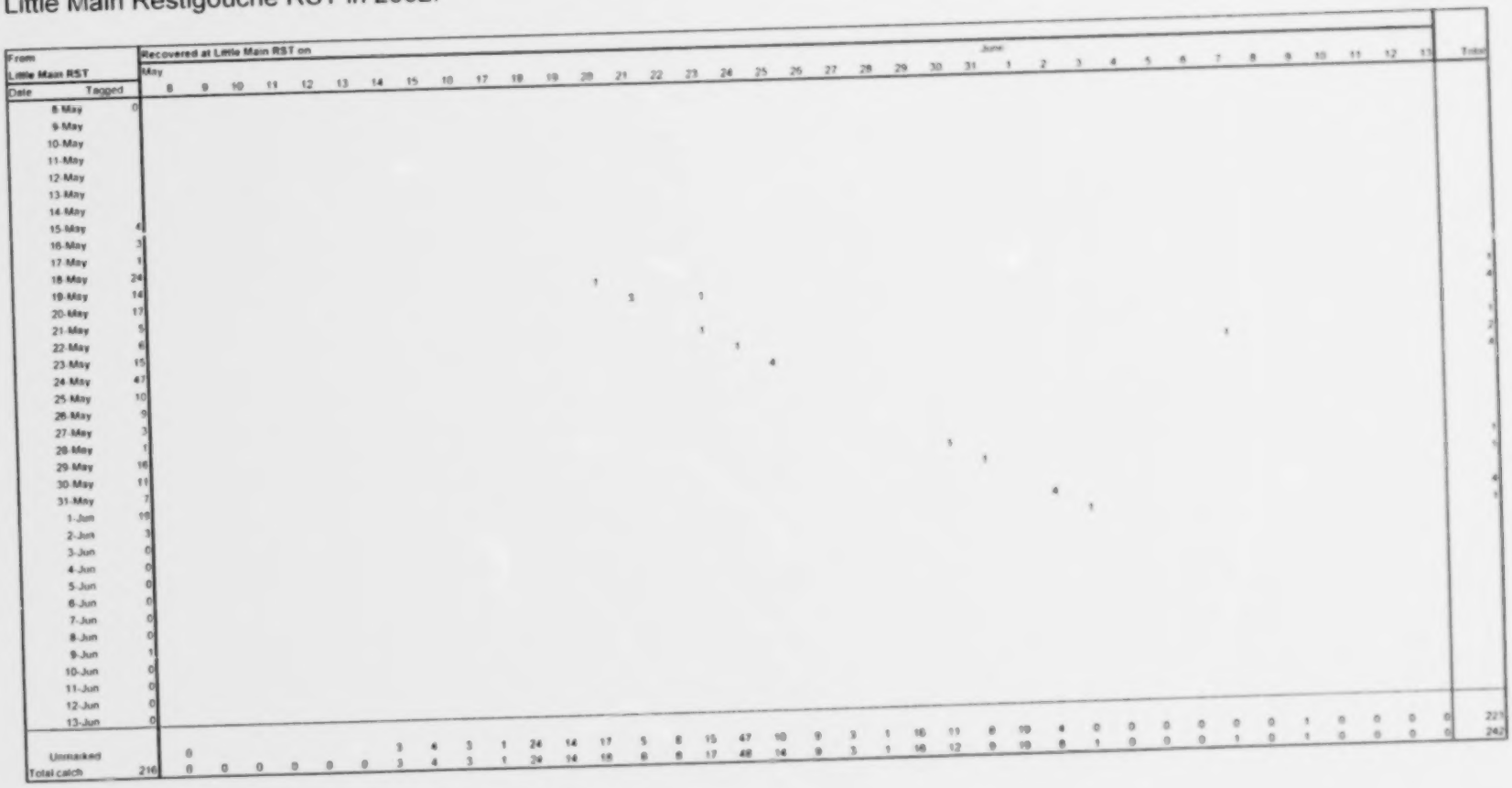


Figure 25. Proportion of tagged groups of smolts from the Kedgwick River RST recaptured at the lower river RSTs in 2003 relative to date of tagging.

Appendix 1. Recapture matrix of smolts tagged at the Kedgwick River RST, recycled and recovered at the Kedgwick RST in 2003.



Appendix 2. Recapture matrix of smolts tagged at the Little Main Restigouche River RST, recycled and recovered at the Little Main Restigouche RST in 2002.



| From Little Main RST | | Recovered at Little Main RST on | | |

Appendix 3. Recapture matrix of smolts tagged at the Kedgwick River RST and recovered at the lower river RSTs in 2003. Unmarked catch excludes recaptures of Kedgwick smolts and recaptures of smolts from lower RST recycling.

From Kedgwick River Date	Tagged	Recovered at the Lower wheels on May 14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	June 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
8-May																																											0
9-May	0																																											0
10-May	3																																											0
11-May	2																																											0
12-May	0																																											0
13-May	3																																											0
14-May	4																																											0
15-May	7																																											0
16-May	7																																											0
17-May	10																																											0
18-May	24																																											0
19-May	51																																											0
20-May	69																																											0
21-May	105													1																														1
22-May	58																1																											1
23-May	62																																											0
24-May	69																1																											1
25-May	92																	1																											1
26-May	109																	2			1																							3
27-May	164																			2																									2
28-May	119																			2		1																							3
29-May	189																					1																							1
30-May	140																							1																					1
31-May	88																						1	1																					2
1-Jun	79																							2																					2
2-Jun	81																									1																			1
3-Jun	60																																												0
4-Jun	26																																												0
5-Jun	18																																												0
6-Jun	12																																												0
7-Jun	22																																												0
8-Jun	13																																												0
9-Jun	6																																												0
10-Jun	0																																												0
11-Jun	2																																												0
12-Jun	0																																												0
13-Jun	2																																												0
14-Jun	0																																												0
15-Jun	0																																												0
16-Jun	1																																												0
17-Jun	3																																												0
18-Jun	1																																												0
19-Jun	3																																												0
Total	1704	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	3	0	4	1	2	1	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
Unmarked Catch		1	3	9	7	25	67	52	119	180	149	171	263	256	237	338	393	349	328	335	105	279	180	129	38	63	54	23	5	11	12	6	5	1	1	2	1	3	0	0	0	4200